Introduction to IPv6: The Need and the Advantages of IPv6

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ABSTRACT

The IP (Internet Protocol) currently used in networks and the Internet is IP version 4 (IPv4). In the last ten years, the Internet has transformed the way people live. The Internet's tremendous growth rate greatly exceeded any futurist's predictions. Therefore, the new version, called IP version 6 (IPv6), resolves unanticipated IPv4 design issues and takes the Internet into the 21st Century. This paper describes the introduction, history and the advantages of IPv6. Some of the advantages are IPv6 offers numerous advantages over IPv4. In this section we will discuss the most prominent ones that are larger address space, faster routing, mobility, quality of service, security, and auto configuration of hosts.

Keywords: Ipv6, IP Addressing, Internet Protocol

INTRODUCTION

The Internet is build upon a protocol suite called TCP/IP. This abbreviation stands for Transmission Control Protocol, and Internet Protocol. When a computer communicates with the Internet a unique IP address is used to transfer and receive information. The IP version currently used in networks and the Internet is IP Version 4 (IPv4). IPv4 was developed in the 70s to facilitate communication and information sharing between government researchers and academics in the United States. At that time, the system was closed with a limited number of access points, and consequently the developer did not envision requirements such as security or quality of service. To its credit, IPv4 has survived for over 40 years and has been an integral part of the Internet revolution. However, today's networking requirements extend far beyond support for web pages and email. Explosive growth in network device diversity and mobile communications, along with global adoption of networking technologies, are overwhelming IPv4 and have driven the development of a next-generation Internet Protocol. IPv6 has been developed based on the rich experience of the developer from developing and using IPv4. Proven and established mechanisms have been retained, known limitations have been discarded, and scalability and flexibility have been expanded. IPv6 is a protocol designed to handle the growth rate of the Internet and to cope with the demanding requirements on services, mobility, and end-to-end security.

The history of IPv6 starts when the Internet Engineering Task Force (IETF) began the effort to develop a successor protocol to IPv4 in the early 1990s. Several parallel efforts to solve the foreseen address space limitation and to provide additional functionality began simultaneously. The IETF started the Internet Protocol-Next Generation (IPng) are in 1993 to investigate the different proposals and to make recommendations for further procedures. The IPng area directors of the IETF recommended the creation of IPv6 at the Toronto IETF meeting in 1994. Their recommendation is specified in RFC 1752, "The Recommendation for the IP Next Generation Protocol." The Directors formed an Address Lifetime Expectation (ALE) working group to determine whether the expected lifetime for IPv4 would allow the development of a protocol with new functionality, or if the remaining time would allow only the development of an address space solution. In 1994, the ALE working group projected that the IPv4 address exhaustion would occur sometime between 2005 and 2011 based on the available statistics.

WHY DO WE NEED IPV6

Organizations and government agencies in the United States use approximately 60 percent of the allocatable IPv4 address space. The remaining 40 percent is shared by the rest of the world. Of the 6.4 billion people in the world, approximately 330 million live in North America, 807 million in Europe, and 3.6 Billion in Asia. This means that the 5 percent of the world's population living in the United States has 60 percent of the address space allocated. Of the 3.6 billion people living in Asia, approximately 364 million have internet access, and the growth rate is exponential.

For example, Stanford University, Xerox, and Apple each have more IPv4 addresses than the whole of China. This is one explanation of why the deployment of IPv6 in Asia is much more common than in Europe and the United States. IP version 4 defines a 32-bit address. This means there are $2^{\wedge 32}$ (4,294,967,296) unique IPv4 addresses available. This may sound like a big number. It is not, most of them are already tied up and the Internet is simply running out of IPs. The address shortage problem is aggravated by the fact that portions of the IP address space have not been efficiently allocated.

Network Address Translation (NAT) was widely implemented to temporarily solve the IP address shortage. A NAT firewall is placed between the real Internet and local area network. NAT allows computers on the local network to connect with the outside world, but because the machines on the local network do not have their own unique Internet IPs they can not be accessed from the outside. This one-way system works, but it destroys the end to end transparency the Internet is based upon. Boxes on the real Internet become servers and the boxes behind NATs become clients.

To separate the addresses used internally (local addresses) and the ones used for the Internet, the Internet authorities have reserved three sets of addresses as private addresses. Table 1.1 shows the three sets used for local addresses. Basically, NAT is similar to PABX which allow extending one phone line, or small set of phone lines to multiple private phone extensions. Here the private extensions are not as publicly reachable phone numbers.

Table 1.1: Addresses used for local network

Range	Total
10.0.0.0 to 10.255.255.255	2^{24}
172.16.0.0 to 172.31.255.255	2^{20}
192.168.0.0 to 192.168.255.255	2^{16}

THE ADVANTAGES OF IPV6 OVER IPV4

IPv6 offers numerous advantages over IPv4. In this section we will discuss the most prominent ones that are larger address space, faster routing, mobility, quality of service, security, and auto configuration of hosts.

The main feature of IPv6 that is driving adoption today is the larger address space. Addresses in IPv6 are 128 bits long versus 32 bits in IPv4. This is a huge 2^{96} increase in the address space.

The larger address space avoids the potential exhaustion of the IPv4 address space without the need for NAT and other devices that break the end-to-end nature of Internet traffic. The drawback of the large address size is that IPv6 is less efficient in bandwidth usage, and this may hurt regions where bandwidth is limited. For corporate networks however, this will simply the already complex method of subnetting.

By using a simpler and more systematic header structure, IPv6 improves the performance of routing. In IPv6 uses a new header format in which options are separated from the base header and placed in extension headers which inserted, when needed, between the base header and the upper-layer data. This simplifies and speeds up the routing process because most of the options do not need to be checked by routers. Every packet-based network has an MTU (Maximum Transmission Unit) size. The MTU is the size of the largest packet which that network can transmit. Packets larger than the allowable MTU must be divided into multiple smaller packets, or fragments, to enable them to traverse the network. In IPv4, packet fragmentation is done in end stations as well as in routers which will use some processing power of the routers, while in IPv6 packet fragmentation is done in end stations. This will take some processing from the routers and lead to faster routing.

When the Internet was first developed, it was intended to be a data-sharing network for the military and for research facilities. No one foresaw its growth as a communications powerhouse, and mobility was merely a concept. There was no need to distinguish between who you were and where you were connected to; it was assumed that they were one and the same. Mobility using IPv4 requires informing any agent in the routing process about a new location, necessitation additional infrastructure that is not always deployed in IPv4 nodes. With mobile IPv6, location is no longer an issue when connection to the Internet. The mobile node sends information about its point of attachment to a home agent, a node on the home network that allows the mobile node to be reachable at its home address regardless of its actual geographic location.

Quality of Service (QOS) is an important term and an emerging feature of modern networks. IPv4 networks typically give each and every packet a "best level of effort" service, even if the content of every packet is not really important or time-sensitive data. An IPv4-based system has no way to differentiate between data payloads that are time sensitive, such as streaming video or audio, and those that are not time-sensitive, such as status reports and file transfer. Streaming audio and video application are very sensitive to delay of a few packets-lips move without sound or picture break up but IPv4 has no way to prevent those problems. If a packet is lost in transit, TCP recognizes the loss and recognizes the loss and requests a retransmission, but only after an inevitable delay. The single delayed TCP packet is probably part of a much larger packet of audio or video data, so the entire big packet is delayed and probably thrown out because the smallest part did not arrive on time. IPv6 provides a way for applications to request handling without delay throughout the WAN. The term often used to describe this is low latency. Streaming audio and video requires low latency through high priority. To prevent a break down in the scheme, the various applications can share connection via priority level.

TCP/IP networks based on IPv4 are plagued with security problems because they are designed to work in a friendly environment and with physically secure connections. When these assumptions are no longer valid-as they are nowadays- the many security weaknesses of IPv4 become manifest and can be easily exploited. IPSEC was introduced by IETF to provide new generic security architecture at the IP level. IPsec is a short for IP Security, a set of protocols developed tp support secure exchange of packets at the IP layer. IPsec has been deployed widely to implement Virtual Private Networks (VPNs). In IPv4, IPsec is add on while it is mandatory in IPv6. IPv6 provides end-to-end security by using authentication extension header, encrypted security payload extension header, or even both of them.

IPv6 hosts can be configured automatically when connected to a routed IPv6 network. When first connected to a network, a host sends a link-local multicast(broadcast) request for its configuration parameters; if configured suitably, routers respond to such a request with a router advertisement packet that contains network-layer configuration parameters. This mechanism called Stateless Mechanism. Another mechanism for automatic connectivity is called Stateful Mechanism. In this mechanism a Dynamic Host Configuration Protocol version 6 (DHCP) is used to provide address configuration and other configuration information. The Neighbour Discovery process is used in IPv6 to self-assigned a link-local address when there is no router or server available. This plug-and-play feature in IPv6, makes it easier for novice users to connect machines to a network. This also addresses the auto configurability needs of nomadic personal computing devices and other emerging technologies.

CONCLUSION

This paper has described the introduction, history and advantages of IPv6 over IPv4. IPv6 has been developed based on the rich experience of the developer from developing and using IPv4. Proven and established mechanisms have been retained, known limitations have been discarded, and scalability and flexibility have been expanded. IPv6 is a protocol designed to handle the growth rate of the Internet and to cope with the demanding requirements on services, mobility, and end-to-end security. The main feature of IPv6 that is driving adoption today is the larger address space. Addresses in IPv6 are 128 bits long versus 32 bits in IPv4. This is a huge 2^{96} increase in the address space. Other advantages of IPv6 are faster routing, mobility, quality of service, security, and auto configuration of hosts.

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