A Comparative Study on IPv4 and IPv6

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***Abstract*--** The addresses of Internet protocol (IP) are a vital resource for the Internet. In the network, IP address is assigned to every interface which connects to the Internet. The addresses are still assigned by using Internet Protocol version 4 (IPv4). IPv4 has demonstrated robust, compatibility with vast range of protocols, applications and easy implementation. IPv4 had been supposed to cover all the network interfaces, however with huge increase of the number of devices (computer, mobile, tablet, routers, server, etc) the reserve of assigned addresses is exhausted. IPv6 has been deployed for providing new services and for supporting the internet growth. This study compares the key specifications of IPv4 and IPv6, contrasts IPv4 and IPv6 header's fields, the structure of headers, explains advantages of IPv6 and disadvantages of IPv4, and why we are running out of IPv4.

Keywords– IPv4; IPv6; IPv4 Header; IPv6 Header; Comparison

I. INTRODUCTION

Internet Protocol (IP) is one of the important protocols in TCP/IP. This protocol identifies hosts and routes data between them over the Internet. The first generation of IP which has been used broadly is IPv4. It had supported growth of Internet for a long time. It was run in a trusted closed environment. Therefore, it didn't require any security mechanism for keeping safe hosts and network elements. IPv4 supposed to be the last version with vast space of addresses (4000 millions). Imaging that these days mobile phones, desktops, androids and huge number of other internet devices connected to the internet. However, the fast expansion of IP makes shortage of IPv4 addresses. IPv4 was sufficient at the time of its beginning, it has never estimated the security, easier configuration, growth the number of IP addresses and quality of service.

The next generation of IP which widely expanded is IPv6. IPv6 was developed to solve the shortage of addressing and most of the IPv4's limitations. The reminder of this study is structured as follows: Section 2 of this paper introduces IPv4. Section 3 briefly describes IPv6. Section 4 contrasts IPv4 and IPv6. Section 5 compares IPv4 and IPv6 header.

II. INTERNET PROTOCOL VERSION 4

In 1978, Internet Protocol version 4(IPv4) was developed and determined in 1981 [1]. The fourth version of Internet Protocol is IPv4 and the first version of Internet protocol that has been widely used. IPv4 uses 32 bit addressing which the capacity of it is 4.3 billion or 2^{32} unique internet addresses. IPv4 involves of five classes, A, B, C, D and E. Class A, B and C specify the different length of host and network. The addresses of class D are used for multicasting group. And class E is kept for future use. Each address involves four 8-octets which resulting an address with 32 bits length. An example of an IPv4 address is 192.168.1.10.

III. INTERNET PROTOCOL VERSION 6

The next generation of IP is Internet Protocol version 6 (IPv6) which intended to succeed IPv4. The development of IPv6 started in 1991 and was integrated in 1997 [2]. Eventually, Internet Corporation for assigned Names and Numbers (ICANN) added the addresses of IPv6 to its DNS server in 2004 [2].
In contrast to IPv4, IPv6 address space is 128 bits. It allows 2^{128} or $3.4 * 10^{38}$ unique addresses [3]. IPv6 addressing format is represented by eight 16-bit hexadecimal number fields which separated by ":". For instance 2201:0000:3838:DCE1:0163:0000:0000:FECB or in the easiest way we are able to write it as 2201:0:3838:DCE1:0163::FECB.

IV. COMPARISON OF IPV4 AND IPV6

There are different differences between IPv4 and IPv6. In the Table 1, IPv4 and IPv6 compared in various concepts, IP addresses, and IP functions.

Table.1 Comparison of IPv4 and IPv6

S.N	***Category***	***IPv4***	***IPv6***
1.	Deployed	1981[1]	1999[1]
2.	Length of address	32 bits (4 bytes)	128 bits (16 bytes)
3.	Total number of addresses	4,294,967,296 unique addresses	340,282,366,920,938,463,463,374,607,431,768,211,456 unique addresses
4.	Style of address	Each IPv4 address is represented in four sets decimal digit, which is divided by dots (“.”). Such as 192.168.10.3, and the limited area of each set is from “0” to “255”.If all digits in each set is zero, we use single zero, for example 192.168.0.0 [4,5].	IPv6 address is represented in eight hexadecimal digit sets, which is divided by colons (“:”). For instance FA90:0000:0000:0000:0301:B3EE:FE1E:8009, If all digits in each set is zero, we put only a double colon. For example FA90::0301:B3EE:FE1E:8009 [4,5].
5.	Type of addresses	Broadcast: the packet is sent to all the interfaces (hosts) [6]. Unicast: the packet is sent to only one interface [6]. Multicast: the packet is sent to some specific interfaces [6].	Multicast: the packet is sent to a number of interfaces [7] unicast: the packet is sent to only an interface [7]. anycast: in this case, a number of interfaces is defined as destinations but the packet is transferred to one of the interfaces which are in set, it depends on routing protocol.
6.	Address Resolution Protocol (ARP)	ARP finds physical addresses, like the MAC or link address, which is associated by an IPv4 address [5].	ARP is substituted with a function of Neighbor Discovery Protocol using IMCPv6 to gain the MAC addresses [4,5].
7.	Communications trace	The task of communications trace is gathering the information of trace of TCP/IP packets which have been entered or leaved.	same in IPv6 [5]
8.	Configuration	IP address is configured by either DHCP or manually [8].	Auto configuration is one of the important features of IPv6. It is known as “plug & play” which allows a node to configure its address by itself. There are two ways of autoconfiguration in IPv6: (1).The stateless autoconfiguration: in this case the address of host doesn’t have to be configured manually, and sometimes routers need minimal configuration.(2).The stateful autoconfiguration: this kind of autoconfiguration is equivalent to the DHCP protocol of IPv4. Here a host gets the IP addresses of its interfaces through a DHCPv6 server that is a pool of addresses which allocated to the interfaces. Auto-configuration is easier and more manageable for large installations [7,8,9].
9.	Domain Name	For mapping the name of hosts to the	For mapping the name of host to the

	Service (DNS)	IPv4 addresses and reverse, it uses host address (A) resource records in DNS [8].	addresses of IPv4 and reverse, it uses host address (AAAA) resource records in DNS [8,10].
10.	DNS record type and location for reverse name resolution	For mapping IPv4 addresses to hosts PTR records in IN-ADDR.ARPA DNS domain [8].	For mapping IPv6 addresses to hosts PTR records in IP6.ARPA DNS domain [8].
11.	Dynamic Host Configuration Protocol (DHCP)	IPv4 is used DHCP to allocate dynamic IP addresses to the various devices over a network.	IPv6 used DHCP[10].
12.	File Transfer Protocol (FTP)	FTP lets you to send and receive information through the network.	FTP doesn't support IPv6 [5].
13.	Fragmentation	when a packet is too big for the next link, it should be fragmented. In IPv4, Sender and forwarding routers are responsible for fragmentation [4].	Sender does fragmentation[12].
14.	Internet Control Message Protocol (ICMP)	network devices use ICMP to send error messages, for example ICMP destination unreachable messages, and informational messages, like ICMP echo request and reply messages [11].	It is used similarly by IPv4; although, ICMPv6 has some more sufficient attributes, such as error reporting in packet processing, diagnostic activities, Neighbor Discovery process and IPv6 multicast membership reporting [11].
15.	Router Discovery	ICMP Router Discovery allows hosts to define the default gateway router to reach devices on different networks, it is important to note that it is optional [12].	ICMPv6 Router Solicitation and Router Advertisement messages work instead of ICMP Router Discovery. It is required [8].
16.	Internet Group Management Protocol (IGMP)	ICMP Router Discovery allows hosts to determine the default gateway router to reach devices on different networks, and it is optional [12]. IGMP is to exchange and update the information of host membership which is in specific multicast groups. Additionally, hosts are able to distinguish interest in gathering multicast traffic from specific sources or specific set of sources [13].	The usage of Multicast Listener Discovery (MLD) is to realize multicast listeners (specific nodes that defined to gathering multicast packets which destined for specific multicast addresses) on the links that are attached directly [14].
17.	Maximum Transmission Unit (MTU)	The maximum size of a packet which can be supported by a specific link is 576 byte [5].	The maximum size of a packet that a particular link can support is 1280 byte [5].
18.	Loopback address	An interface by one address of 127.*.*.* are a loopback address which a node can use it to send a packet to itself. The name of physical address is *LOOPBACK [5].	The loopback address is 0000:0000:0000:0000:0000:0000:0000:0001 or ::1. The name of physical address is *LOOPBACK [5].
19.	Network address Translation (NAT)	NAT is a process to assign a public IP address to network devices, usually Firewalls. NAT's purpose is to decrease the amount of public addresses [5].NAT gives IP addresses which are private to the users then a group of users can get the internet by using a public IP address. So, NAT has faced a lot of problems: (1) NAT	IPv6 doesn't require NAT [5].

		makes problem in RTC (Real Time Communication) protocol. RTC is used for VoIP and multimedia communication. (2) It makes security problems. Because it has to change the IPSec headers as well as it harms the end to end security and data integrity (3) Peer to peer communication needs unique IP address. NAT creates peer to peer communication problem because it is difficult to establish a proper connection between users with the public IP usage [15].	
20.	Routing protocols	RIP,RIP-2,IGRP,EIGRP,OSPF-2,OSPF-3,MOSPF,IS-IS,DVMRP,PIM,EGP,BGP-4[16].	RIPng,OSPF-3,EIGRP,IS-IS,PIM,BGP-4[16].
21.	Quality of Service	QoS lets you to demand packet bandwidth and priority for TCP/IP application [14]. In other word, QoS is a mechanism to transfer a multimedia packet such as music, voice and video with good quality but in IPv4 there isn't any assurance that all QoS compliant devices are compatible with another device [17].	In Ipv6 there is a field which is known as Flow Label field. This field defines how specific packets are identified as well as carried by the routers. The Flow Label field lets the packets which begin from a specific host to a particular destination to be identified and handled by the routers [17]. The purpose of QoS mechanisms are [7]: - Real time application. - Less latence and "jitter". - More tolerance to packet losses. - Retransmissions are less important. - More importance of the temporal relationship.
22.	Renumbering	When we are interested in extending a network or merging the networks we have to renumber the IP addresses of networks, And it is done manually. This is a troublesome and difficult process [5].	Renumbering is one of the important elements of IPv6, and it is automatic [5].
23.	Simple Network Management Protocol (SNMP)	SNMP is used for managing a system [5].	Doesn't use in IPv6 [5].
24.	Virtual Private Network (VPN)	VPN lets you to explode a private network on a public network [5].	VPN supports IPv6 [5].
25.	Security	Security is bounded to tunnelling between two networks [18].	IPv6 provides data security, which involves end-to-end backing for user authentication, data encryption and data integrity [18].
26.	IPSec support	Optional[10]	One of the important protocols in IPv6 is IPSec. It involves a set of cryptographic protocols for making secure communication and key exchange. The major protocols used are: (1) Authentication Header (AH) Protocol: it enables authentication and integrity of data. (2) Encapsulating Security Payload (ESP): ESP enables authentication, integrity of data and privacy of data .(3) Internet Key Exchange (IKE): this protocol

			sets up the security between two end points and holds the track of information therefore the communication will be secured until the end [10,17,19].
27.	Mobility	Ipv4 doesn't support mobility and handover. It means if a mobile node changes its location then the address of node needs to be established again [1]. Mobile IPv4 (MIPv4) is used by IPv4 [10].	Use MIPv6 with faster routing, handover and hierarchical mobility [10].

V. COMPARISON OF IPV4 AND IPV6 HEADER

IPv4 header outlined in the Fig 1 [21]:

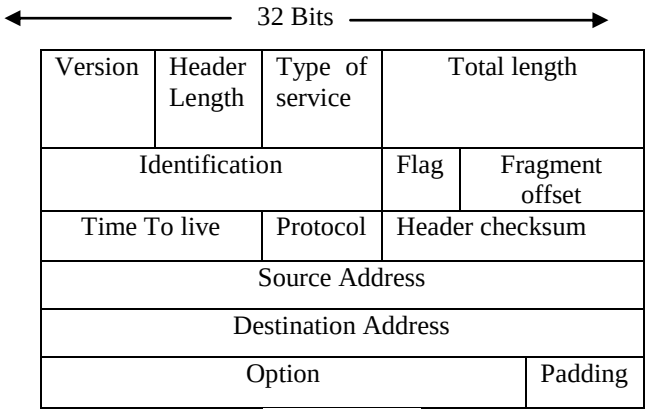

Fig. 1 IPv4 header

IPv6 header has removed all the useless options and added some of them into a field which is called extension header. The Fig 2, shown the IP header of IPv6 [21]:

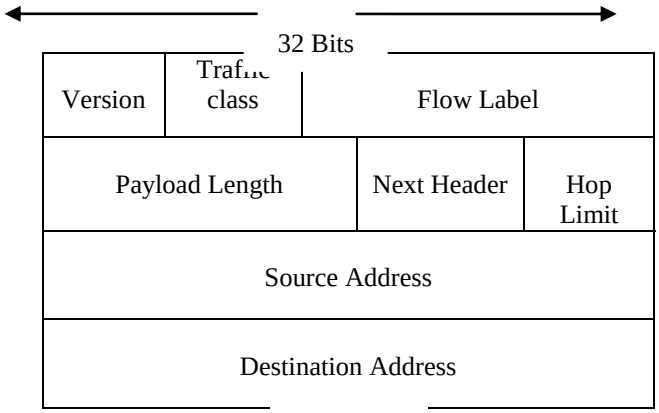

Fig. 2 IPv6 header

In the table 2, you can see a comparative study of IPv4 and IPv6 headers:

Table. 2 Compare IPv4 and IPv6

S.N	***IPv4 Header's Field***			***IPv6 Header's Field***		
	Name of Field	**Length**	**Description**	**Name of Field**	**Length**	**Description**
1.	Version	4 bits	This field's value is the version of IP. In IPv4 the value of this field is 4.	Version	4 bits	The value of this field is 6.
2.	Header Length	4 bits	Header's length	Header Length Field is removed in IPV6 Header [24].	___	___
3.	Type of Service	8 bits	The way that a datagram has to be carried [21].	Traffic class	8 bits	The function is same as Type of Service Field in IPv4 [24].
4.	There is no Flow Label Field in IPv4 Header	____	___	Flow Label	20 bits	QoS is a mechanism to transfer a multimedia packet like voice, video and music. The functionality of Flow Label field

						is same as QoS.
5.	Total Length	16 bits	Gives router the total length of IP header and data [21].	Payload Length	16 bits	The process is similar to Total Length Field in IPv4[24]
6.	Identification	16 bits	It identifies the value is allocated by the sender to help in assembling the fragments of a datagram [21].	Identification Field is removed in IPV6 Header	___	This field is removed in ipv6 header [24].
7.	Flags	3 bits	It specifies an IP packet might be fragmented or not [13,21].	Flags Field is removed in IPV6 Header	___	This field is removed in ipv6 header [24].
8.	Fragment offset	13 bits	It shows the exact location of a datagram in a fragment [15, 21].	Fragment Offset Field is removed in IPV6 Header	___	This field is removed in ipv6 header [24].
9.	Time To live	8 bits	It displays the maximum time when a datagram is permitted to be up in the Internet system. [21].	Hop Limit	8 bits	The function is similar to Time To live Field in IPv4
10.	Protocol	8 bits	At destination host, it defines the protocol that the packet belongs to at the next level [13, 21].	Next Header	8 bits	The function is similar to Protocol Field in IPv4
11.	Header Checksum	16 bits	It surveys whether the packet received error-free [13, 21].	Header Checksum Field is removed in IPV6 Header	___	It is handled by upper-layer protocols. Thus, it is removed in IPv6.
12.	Source Address	32 bits	The address of sender.	Source Address	128 bits	The address of sender.
13.	Destination Address	32 bits	The address of receiver.	Address	128 bits	The address of receiver.
14.	Options	Variable	This field is optional. These options can involve values for options like Security, Record Route, Time Stamp and etc [13, 21].	Option Field is removed in IPV6 Header	___	Added into Extension header
15.	Padding	Variable	Padding will be added at the end of a packet by header length field if the size of header is less than standard size. [13, 21].	Padding Field is removed in IPV6 Header	___	Added into Extension header

16.	There is no Extension headers Field in IPv4 Header	___	___	Extension headers	Variable	Extension Field is added into IPv6 Header. It handles security and the function of options field in IPv4 [24]

VI. CONCLUSION

In this paper we compared IPv4 and IPv6 in history, address structure, header's structure, the fields of headers, security, routing protocols, IP address configuration, function of different protocols, etc. IPv4 is the first version of IP which has been used globally. When IPv4 was designed, it was estimated to be used for a long time, but the number of devices which are able to connect network is increasing, so that IPv4 faced some problems. In this study we found the main drawbacks of IPv4 and the major features of IPv6 that eliminates the drawbacks of IPv4. Address shortage is one of the important problems of IP, people use multiple devices like PC, laptop, PDA and phones thus the request for IP addresses is raising thus the number of IPv4 addresses is being a problem in future. IPv6 provides larger address space, the length of address in IPv4 is 32-bit, it is increased to 128-bit in IPv6. Mobility is another drawback of IPv4, if a mobile node changes its location, it will lose the current IP address and it should be established again. In contrast of IPv4, IPv6 enhances mobility. IPv6 allows mobile nodes to change their location without dropping the IP address. The security field (IPsec) in IPv4 is optional and all the responsibility of security belongs to the end nodes which is not safe. IPv6 header contains IPsec field, and it is required. This field is implemented by using AH, ESP and IKE. In IPv4, the configuration of IP is done by either manually or DHCP but IPv6 made configuration easy by using auto configuration. According to the previous considerations, IPv6 protocol will be better as compared to the IPv4 protocol. It has arrived as the next generation Internet Protocol and provides several functionalities to eliminate the limitations of IPv4.

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