

# Evaluation of Internet Protocol Addressing and Comparison between Ipv4 & Ipv6: A Study

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## ABSTRACT

*The TCP/IP protocol suite is so named for two of its most important protocols namely Transmission Control Protocol (TCP) and Internet Protocol (IP). TCP/IP is an industry standard suite of protocols that is designed for large networks consisting of network segments that are connected by routers. TCP/IP is the protocol that is used on the Internet, which is the collection of thousands of networks worldwide that connect research facilities, universities, libraries, government agencies, and individuals. Present paper provides an introduction to IPv6 by giving the results that can be obtained by deploying the technology. It explains some of the technical features and advantages of IPv6.*

**Keywords**–Internet protocol version 4 (IPv4); Internet protocol version 6 (IPv6); Network broadcast; Broadcast address; Multicast address Subnet broadcast and Loopback address

## 1. INTRODUCTION

Transmission control protocol/Internet protocol TCP/IP– A suite of networking protocols, including both IPv4 and IPv6, that are widely used on the Internet and that provide communication across interconnected networks of computers with diverse hardware architectures and various operating systems. The main design goal of TCP/IP was to build an interconnection of networks, referred to as an internetwork, or internet, that provided universal communication services over physical networks. The clear benefit of such an inter

network is the enabling of communication between hosts on different networks separated by a large geographical area.

## 2. HISTORY OF TCP/IP

In 1970, ARPANET hosts started to use Network Control Protocol (NCP), a preliminary form of what would become the Transmission Control Protocol (TCP). In 1974, the Transmission Control Protocol (TCP) was specified in detail. TCP replaced NCP and provided enhanced reliable communication services. In 1981, the Internet Protocol also known as IP version 4 (IPv4) was specified in detail.

IP provides addressing and routing functions for end-to-end delivery. In 1982, the Defense Communications Agency (DCA) and ARPA established the Transmission Control Protocol (TCP) and Internet Protocol (IP) as the TCP/IP protocol suite. In 1983, ARPANET switched from NCP to TCP/IP. In 1996, the first set of IP version 6 (IPv6) standards were published. On a TCP/IP based network, a router can forward packets that are not addressed to the router, a host cannot, and a node is either a host or a router. Ipconfig and Ping are the primary tools for troubleshooting basic IP configuration and connectivity.

## 3. THE TCP/IP PROTOCOLS SUITE

The TCP/IP protocol suite maps to a four-layer conceptual model known as the DARPA model, which was named after the U.S. government agency that initially developed TCP/IP. The four layers of the DARPA model

are Application, Transport, Internet, and Network Interface. Each layer in the DARPA model corresponds to one or more layers of the seven layers OSI model.

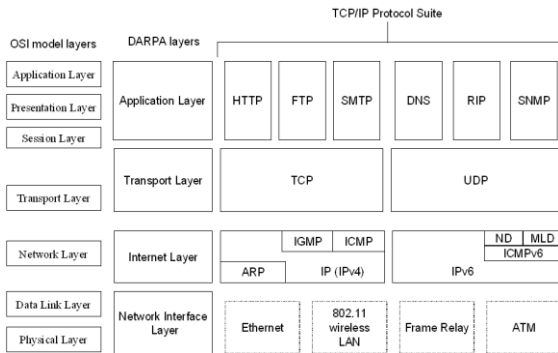


Fig.1 The architecture of the TCP/IP protocol suite

The TCP/IP protocol suite has two sets of protocols at the Internet layer:

**3.1. IPv4** is the Internet layer in common use today on private Intranets and the Internet.

**3.2. IPv6** is the new Internet layer that will eventually replace the existing IPv4 Internet layer.

#### 4. INTERNET PROTOCOL VERDION 4 (IPv4)

IPv4 is a datagram protocol primarily responsible for addressing and routing packets between hosts. IPv4 is connectionless, which means that it does not establish a connection before exchanging data, and unreliable, which means that it does not guarantee packet delivery. IPv4 always makes a “best effort” attempt to deliver a packet. An IPv4 packet might be lost, delivered out of sequence, or delayed. IPv4 does not attempt to recover from these types of errors. A higher-layer protocol, such as TCP or an application protocol, must acknowledge delivered packets and recover lost packets if needed. IPv4 is defined in RFC 791. An IPv4 packet consists of an IPv4 header and an IPv4 payload. An IPv4 payload, in turn, consists of an upper layer protocol data unit, such as a TCP segment or a UDP message.

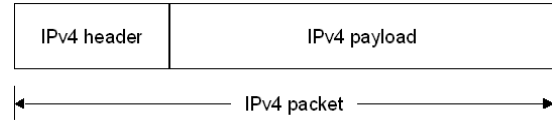


Fig.2 The basic structure of an IPv4 packet

**4.1. IPv4 Address:** An IP address is an identifier that is assigned at the Internet layer to an interface or a set of interfaces. Each IP address can identify the source or destination of IP packets. The IPv4 address is a logical address because it is assigned at the Internet layer and IPv4 addresses are 32 bits long.

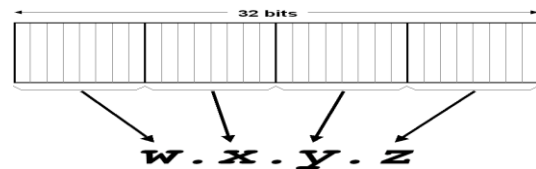


Fig.3 IPv4 address in dotted decimal notation

Where W, X, Y, Z are called octets and each octet is of 8 bits.

**4.2. Classes of IPv4 Address:** IPv4 addresses are classified into five classes as given below:

Class	Range	Left most Bits	# of Network Bits	# of Host Bits	# of Networks available	# of Hosts available	Used
A	1-127	0	8	24	126	16777214	LAN/WAN
B	128-191	10	16	16	16384	65534	LAN/WAN
C	192-223	110	24	8	2097152	254	LAN/WAN
D	224-239	1110	N/A	N/A	N/A	N/A	Multicasting
E	240-255	1111	N/A	N/A	N/A	N/A	R & D

Fig.4 IP address classification

There are three types of Internet addresses as defined below:

**4.3. Unicast Address:** Assigned to a single network interface located on a specific subnet used for one-to-one communication. The IPv4 unicast address identifies an interface's location on the network in the same way that a street address identifies a house on a city block. IPv4 unicast address must be globally unique and have a uniform format and each IPv4 unicast address includes a subnet prefix and a host ID portion as given below.

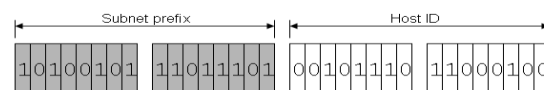


Fig.5 Structure of an example unicast IPv4 address

**4.4.MulticastAddress:**Assigned to one or more network interfaces located on various subnets used for one-to-many communication. IPv4 uses multicast addresses to deliver single packets from one source to many destinations. On an IPv4 intranet that is enabled for multicast, routers forward an IPv4 packet addressed to an IPv4 multicast address to the subnets on which hosts are listening to the traffic sent to the IPv4 multicast address. IPv4 multicast efficiently delivers many types of communication from one source to many destinations. IPv4 multicast addresses are defined by the class D Internet address class: 224.0.0.0/4. IPv4 multicast addresses range from 224.0.0.0 through 239.255.255.255. IPv4 multicast addresses for the 224.0.0.0/24 address prefix (224.0.0.0 to 224.0.0.255) are reserved for multicast traffic on a local subnet.

**4.5.BroadcastAddress:** Assigned to all network interfaces located on a subnet used for one-to-everyone on a subnet communication. IPv4 uses a set of broadcast addresses to deliver packets from one source to all interfaces on the subnet. All the interfaces on the subnet process packets sent to IPv4 broadcast addresses. The following are the types of IPv4 broadcast addresses:

**4.5.1.Network Broadcast:** Formed by setting all the host bits to 1 for a classful address prefix. For example, 131.107.255.255 is a network broadcast address for the classful address prefix 131.107.0.0/16. Network broadcasts send packets to all interfaces of a classful network. IPv4 routers do not forward network broadcast packets.

**4.5.2.Subnet Broadcast:** Formed by setting all the host bits to 1 for a classless address prefix. For example, 131.107.26.255 is a network broadcast address for the classless address prefix 131.107.26.0/24. Subnet broadcasts are used to send packets to all hosts of a classless network.

**4.6.Loopback Address:** It is known as the IPv4 loopback address, it is assigned to an internal loopback interface. This interface enables a node to send packets to itself. 127.0.0.1 is an example of loopback address.

## 5. INTERNET PROTOCOL VERSION 6 (IPv6)

IPv6 is a connectionless, unreliable datagram protocol that is primarily responsible for addressing and routing packets between hosts. IPv6 defines many improvements over IPv4. However, the primary goal of IPv6 is to significantly increase the number of available IP addresses. To that end, IPv6 uses a 128 bits IP address, rather than 32 bits defined by IPv4. A 32-bits address space allows for  $2^n$  where  $n=32$  or 4.3 billion addresses. A 128-bits address space allows for  $2^n$  where  $n=128$  or 340 undecillion (340 followed by 36 zeros) possible addresses. For IPv6, the 128-bits address is divided along 16-bit boundaries, each 16 bits block is converted to a 4 digit hexadecimal number and adjacent 16 bit blocks are separated by colons. RFC 4291 describes the IPv6 addressing architecture. RFC 2460 defines IPv6 packet structure. An IPv6 packet consists of an IPv6 header and an IPv6 payload. The IPv6 payload consists of zero or more IPv6 extension headers and an upper layer protocol data unit, such as an ICMPv6 message, a TCP segment, or a UDP message. Figure below shows the basic structure of an IPv6 packet.

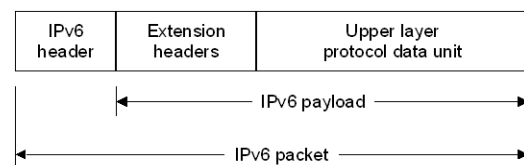


Fig.6 Basic structure of an IPv6 packet

## 6. TYPES OF IPV6 ADDRESS

IPv6 uses unicast addresses, multicast addresses, and anycast addresses to deliver a packet from one source to one of many destinations. A unicast address identifies a

single interface within the scope of the type of unicast address. With the appropriate unicast routing topology, packets addressed to a unicast address are delivered to a single interface. A unicast address is used for communication from one source to a single destination. A multicast address identifies multiple interfaces. With the appropriate multicast routing topology, packets addressed to a multicast address are delivered to all interfaces that are identified by the address. A multicast address is used for communication from one source to many destinations, with delivery to multiple interfaces. An anycast address identifies multiple interfaces. With the appropriate routing topology, packets addressed to an anycast address are delivered to a single interface, the nearest interface that the address identifies.

**6.1. IPv6 Unicast Address:** The following types of addresses are unicast IPv6 addresses:

**6.1.1. Global Unicast Address:** Global unicast addresses are equivalent to public IPv4 addresses. They are globally routable and reachable on the IPv6 portion of the Internet, known as the IPv6 Internet.

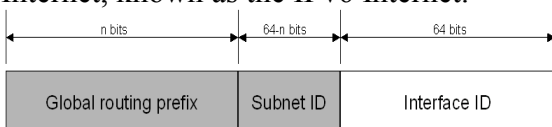


Fig.7 Structure of a global unicast address

**6.1.2. Link-Local Address:** Nodes use link-local addresses when communicating with neighboring nodes on the same link, also known as a subnet. A link-local address is required for Neighbor Discovery processes and is always automatically configured, even in the absence of all other unicast addresses.

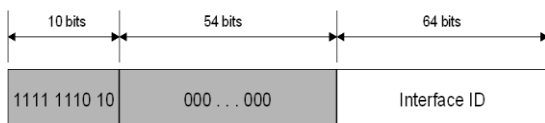


Fig.8 Structure of the link -local address

**6.1.3. Site-Local Address:** Site-local addresses are equivalent to the IPv4 private address

space. Site-local addresses are not automatically configured and must be assigned either through stateless or stateful address configuration.

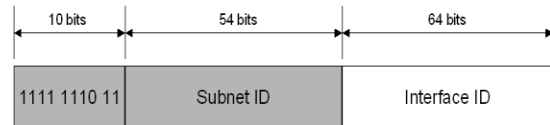


Fig.9 Structure of the site-local address

**6.1.4. Unique Local Address:** RFC 4193 defines unique local IPv6 unicast addresses. Figure below shows the structure of unique local addresses.

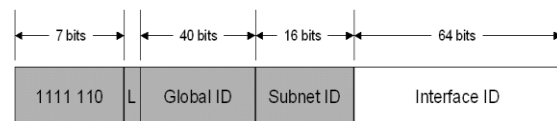


Fig.10 The unique local address

The first 7 bits have the fixed binary value of 1111110. All unique local addresses have the address prefix FC00::/7. The Local (L) flag is set 1 to indicate a local address. The L flag value set to 0 has not yet been defined. Therefore, unique local addresses with the L flag set to 1 have the address prefix of FD00::/8. The Global ID identifies a specific site within an organization and is set to a randomly derived 40-bit value.

**6.1.5. Special IPv6 Address:** IPv6 has a slightly complex structure of IP address than that of IPv4. IPv6 has reserved a few addresses and address notations for special purposes.

IPv6 address	Meaning
::/128	Unspecified address
::/0	Default Route
::1/128	Loopback address

Fig.11 Special IPv6 address

**6.1.6. Transition Address:** The IPv4 compatible address, 0:0:0:0:0:w.x.y.z or ::w.x.y.z where w.x.y.z is the dotted



decimal representation of a public IPv4 address is used by IPv6/IPv4 nodes that are communicating using IPv6. IPv6/IPv4 nodes are nodes with both IPv4 and IPv6 protocols. When the IPv4 compatible address is used as an IPv6 destination, the IPv6 traffic is automatically encapsulated with an IPv4 header and sent to the destination using the IPv4 infrastructure. IPv4 mapped addresses are used for internal representation only. It is never used as a source or destination address of an IPv6 packet. The 6to4 address is used for communicating between two nodes running both IPv4 and IPv6 over the Internet. It can be formed the 6to4 address by combining the global prefix 2002::/16 with the 32 bits of a public IPv4 address of the node, forming a 48-bit prefix. 6to4 is an IPv6 transition technology described in RFC 3056.

**6.2. IPv6 Multicast Address:** IPv6 multicast addresses have the first eight bits fixed at 1111 1111. Therefore the address prefix for all IPv6 multicast addresses is FF00::/8. Beyond the first eight bits, multicast addresses include additional structure to identify flags, their scope, and the multicast group.

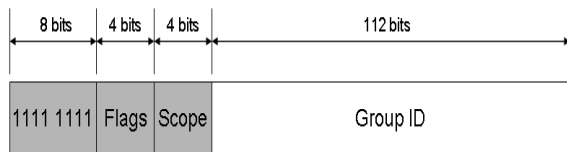


Fig.12 The structure of the IPv6 multicast address

**6.3. IPv6 Anycast Address:** An anycast address is assigned to multiple interfaces. The routing structure forwards packets addressed to an anycast address so that they reach the nearest interface to which the anycast address is assigned. To facilitate delivery, the routing infrastructure must be aware of the interfaces assigned anycast addresses and their “distance” in terms of routing metrics. At present anycast addresses are used as destination addresses only.

## 7. COMPARISON OF IPv4 AND IPv6

IPv4 address	IPv6 address
It is internet protocol version 4.	It is internet protocol version 6.
It is 32 bits, 4 octets	It is 128 bits, 16 octets
No. of addresses 4.3 billion	No. of addresses 340 undecillion
Internet address classes available	Not applicable in IPv6
IPv4 multicast addresses (224.0.0.0/4)	IPv6 multicast addresses (FF00::/8)
Support Broadcast addresses	Not applicable in IPv6
Public IPv4 addresses	Global unicast addresses
Address syntax: dotted decimal notation	Address syntax: colon hexadecimal format
Unspecified address is 0.0.0.0	Unspecified address is ::

## 8. ADVANTAGES OF IPv6

To continue the growth of the Internet and private intranets, IPv4 must eventually be replaced. The following are the key technological and business benefits in the case to deploy IPv6.

### 8.1. Large Address Space

- Global reachability and flexibility
- Aggregation
- Auto configuration
- Plug and Play
- Support for encapsulation of itself and other protocols.
- Compatibility methods to coexist and communicate with IPv4.

### 8.2. Mobility and Security

- Mobile IP
- IPSec Native (default , Mandatory)
- Built-in authentication and encryption

### 8.3. Simpler Header

- Performance and forwarding scalability
- No Broadcast



- No checksum
- Extension Header
- No fragmentation
- Flow label

#### 8.4. Translation Richness

- Dual Stack
- 6to4 or 4to6 Tunnels
- Translation

### 9. CONCLUSION

IPv6 represents one of the most significant technology changes in the history of the Internet. The Internet is at an inflection point. Urgency centering on IPv6 is being driven by the exhaustion of IPv4 addresses, which has already occurred around the world. IPv6 holds the key to continue growth of the Internet. IPv6 deployment will happen and IPv4 will go away. The Internet will continue to grow and the numbering system and the routing system will change to accommodate that growth. The most obvious change in going from IPv4 to IPv6 is the increase in the address space from 32 bits in IPv4 to 128 bits in IPv6. This will allow for the connection of far more devices to the Internet or any network using Internet Protocol.

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