

Internet Protocol Assessment

IPv6 Research Report of IPv6 Addressing



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IPv6 Addressing Research Report

Introduction to IPv6

IPv6 is the next generation of IP, designed to coexist along with his predecessor IPv4. The new protocol provides several advantages over IPv4. IPv6 was initially developed due to the lack of IP address provided by IPv4. As a protocol still in development process it has his weaknesses (Dawood, 2016) (Bajaj, 2019).

IPv6 also called IPng (or IP NEXT Generation), allows substantially more IP address then IPv4, typically written in this format: “FE80:0A3B:0002:4B3C:0123:4567:89AB:CDEF”. Today computer systems support IPv6, but only the government systems and some major companies are demented to use it. During this period PC’s are often assigned with both addresses (Christensson, 2006).

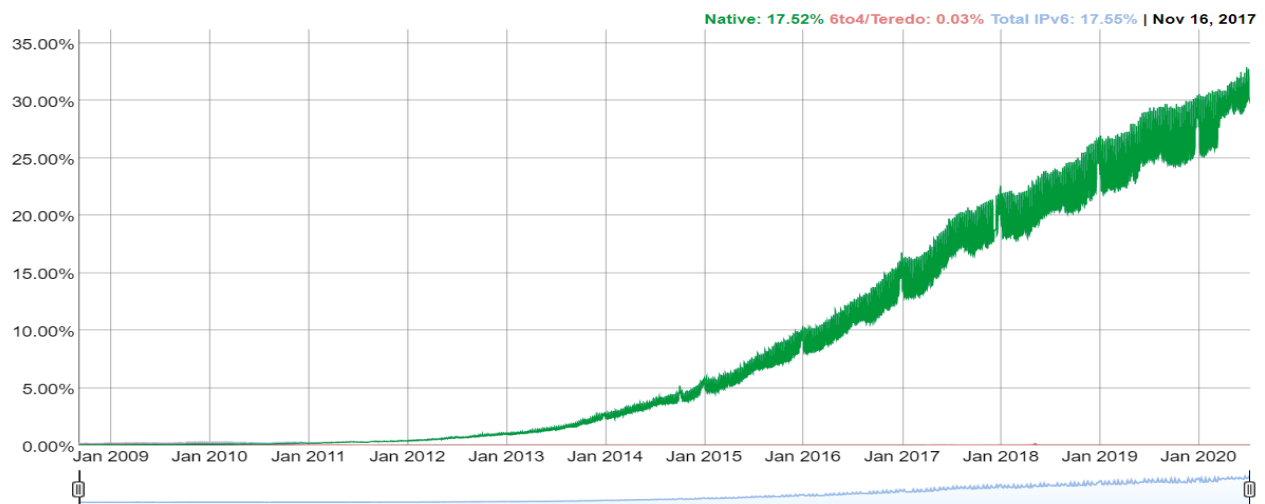
QoS – IPv6 provides a set of services that are required for best performance while communicating throughout the network. The QoS is the Quality of Service developed to ensure that new technology like audio/video streaming, IP phones and Online Games do not experience any difficulties, lags or lost of data.

On 3 February 2011, (ICANN) the Internet Corporation for Assigned Names and Numbers announced that all the public IPv4 addresses are now completely allocated (Davies, 2012, p. 1).

From that moment the chart began to rise as show in the diagram:

IPv6 Adoption

We are continuously measuring the availability of IPv6 connectivity among Google users. The graph shows the percentage of users that access Google over IPv6.



Google IPv6 Adoption Diagram 2020

<https://www.google.com/intl/en/ipv6/statistics.html>

IPv6 Header Specifications

IPv6 Header is a streamlined version of the IPv4 version and it is always present with fixed size of 40 bytes. It eliminates that field that are unused or unneeded and adds one that provides greater support for real-time traffic.

IPv6 has simpler header - because we do not use checksum, Routers do not need to calculate them for each packet (Oracle, 2011). IPv6 packet is split into a main fixed header and extension headers. Those packets usually are encapsulated in a frame and send over the Ethernet or link-layer or even with Tunneling Protocol, using Teredo or 6to4 technologies.

Since July 2017, IANA the Internet Assigned Numbers Authority is responsible for the registration of all IPv6 parameters, that are used in IPv6 header packets (Jia, et al., 2019).

Comparing both IPv4 and IPv6 Headers:

IPv6 Header

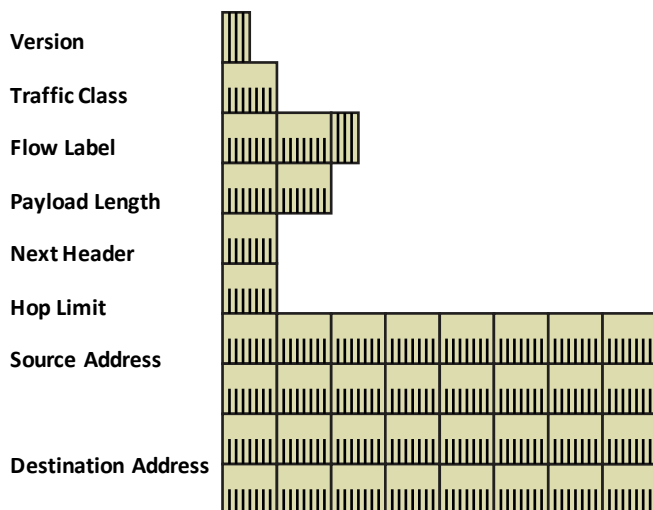


Figure 1 (Davies, 2012)

IPv4 Header

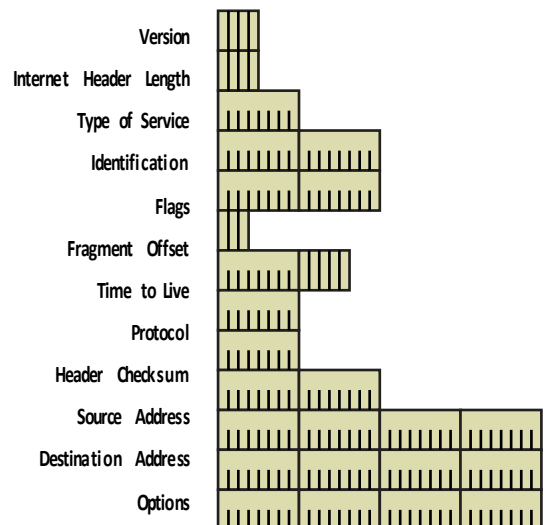


Figure 2 (Davies, 2012)

Fixed Header Description

IPv6 address is four times larger than IPv4 address as we have seen from (Figure1&2), The header is two times bigger. Bild from 1 Fixed Header followed by one/many or none Optional Headers. The mane information needed to transport that packet from “source to destination” is been imprinted inside The Fixed Header (Davies, 2012).

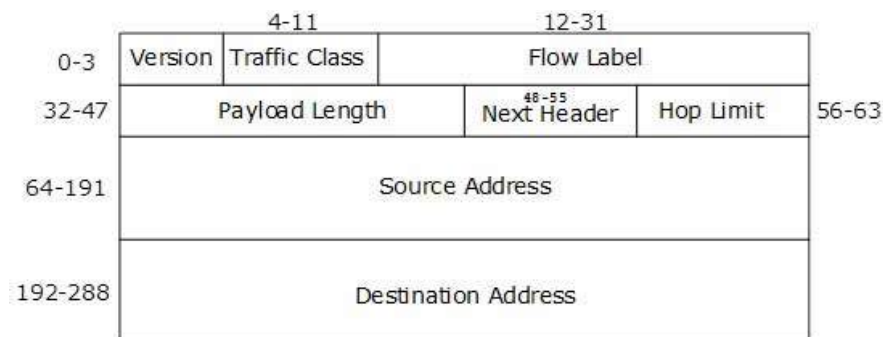


Figure 3 (Oracle, 2011)

Description of Figure 3:

- 1) **Version** – represent the version of Internet Protocol we are using. (Occupies 4 bits)
- 2) **Traffic Class** – (next 8 bits)
 - a. 0-6 bits represent the service type – Giving the router knowledge about what service should be used in this case .
 - b. Next two bits are assigned for Explicit Congestion Notification. That means even if the network is overloaded, end-to-end notification will be available without dropping any packets. (RFC 3168)
- 3) **Flow label** (next 20bits) – designed for streaming real-time media, by maintaining the sequential flow of the packets.
- 4) **Payload Length** (next 16 bits) – tells the router how much info contains in the packet payload. Payload is composed of Extension Headers and Upper Layer data. With 16 bits, up to 65535 bytes can be indicated; but if the Extension Headers contain Hop-by-Hop Extension Header, then the payload may exceed 65535 bytes and this field is set to 0.
- 5) **Next Header** (next 8 bits) – shows the type of The Extensional Header. If there is none, then it indicates the Upper Layer.
- 6) **Hop Limit** (next 8 bits) – we use this field to stop packet looping for infinity like with TTL in IPv4. As it passes a link (hop) The value of Hop Limit field is decremented by 1. After 0 the packet drops.
- 7) **Source Address** (next 128 bits) – shows the source Address of the packet.
- 8) **Destination Address** (next 128 bits) – shows the recipient's address

Extension Header Sequence

In IPv6, the fixed Header is carrying specific information, strictly important. Any other information that is not required or not used often we put between the next Layer Header and The Extension Headers. Each has their distinct value used for identification (Davies, 2012) (Oracle, 2011).

When Extension Header is used it allocate yourself on the field right after the Fixed Header's field. If there is another Extension Header, then it allocates as follow, right after the first Extension Header. The last Extension Header's "Next-Header" field brings the Upper Layer Header. And to the next and so on.

If we reach to Header field with the value of 59, that means we have reached the end.

RFC 2460 supports The Extensional Headers:

Extension Header	Next Header Value	Description
Hop-by-Hop Options header	0	read by all devices in transit network
Routing header	43	contains methods to support making routing decision
Fragment header	44	contains parameters of datagram fragmentation
Destination Options header	60	read by destination devices
Authentication header	51	information regarding authenticity
Encapsulating Security Payload header	50	encryption information

(Oracle, 2011)

Extension headers Flow:

IPv6 header
Hop-by-Hop Options header
Destination Options header ¹
Routing header
Fragment header
Authentication header
Encapsulating Security Payload header
Destination Options header ²
Upper-layer header

IPv6 Addressing Types

An IPv6 uses 128-bit address split in 8 octets of 4 hexadecimal digits. The address looks like this: FE80:0C7B:F042:4D8B:0A7B:3C4D:FCF5:006B

We have the ability to omit all leading zeros and represent the address like this: FE80:C7B:F042:4B3C:A7B:3D4D:FCF5:6B

IPv6 Loopback address – used on a loopback interface: 0:0:0:0:0:0:1, or notated like this: “::1/128”

Unspecified address – 0:0:0:0:0:0:0:0 or ::/128

In IPv4, we are using 3 types of addresses: Unicast, Multicast and Broadcast. In IPv6 we are swapping Broadcast with Anycast:

I. Unicast Addresses: represent single interface. When we send a packet through the network to a unicast address, that packet travels directly to that interface specified by that address. There are 128 bits reserved for the interface and x bits for the prefix (Cisco, 2020).

Types:

- 1) Global unicast address – is assigned to a host address. We use them as a public addresses like in IPv4, they have a global scope and start with 2000::/3.
- 2) Link-local address – always have the prefix FE80::/10 and is used for communication between host login in a same network or using the same link. Here we are talking about Local scope that are used strictly inside the network.
- 3) Unique local – used for private addressing. Communicate throughout the network segment and being routable to a several local networks. They start with prefix FD00::/8

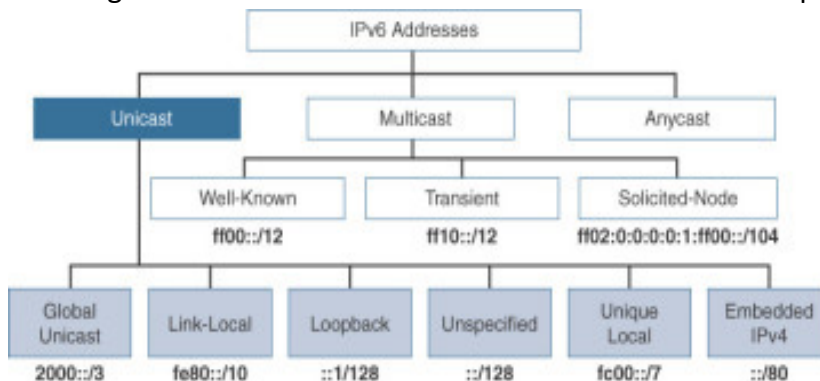


Figure1

Unicast address has the ability to identify an interface on an IPv6 host. When we send a packet to a unicast address, it got received by interface the assigned to the address (Graziani, 2017).

II. Multicast Address: is a Protocol used to deliver data like audio/video stream broadcast to a multiple host. With multicast, we can send data to a single multicast address and then deliver to an entire group of users. Large companies like Netflix must use multicast to deliver their service. There is a lot unicast traffic going on in their network (Cisco, 2020).

In an IPv6 subscriber access network we can use the following types of multicast addresses:

- 1) Solicited-node address
- 2) All-nodes address
- 3) All-routers address

Multicast addresses have the prefix FF00::/8.

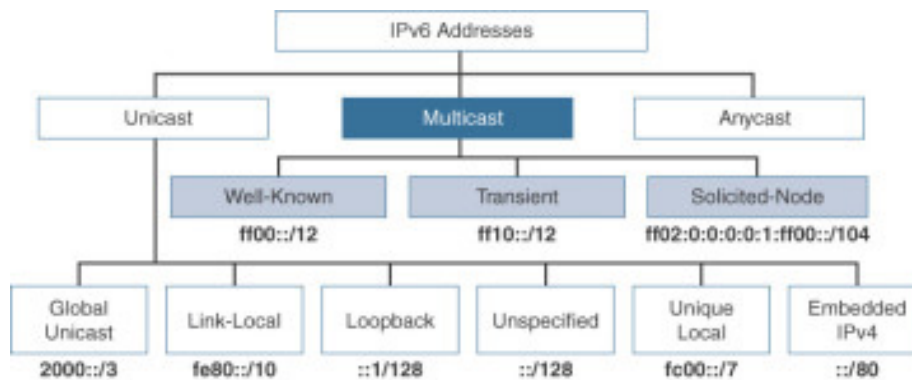


Figure1

Figure1 represents the multicast addresses types. Technique we use to allows device to send simultaneously single packet to multiple hosts. They could have several interfaces on that device, but usually they are different. (Graziani, 2017)

Representation	IPv6 Multicast Address
Preferred	FE80:0C7B:F042:4D8B:0A7B:3C4D:0000:006B
Leading 0s omitted	FE80:C7B:F042:4D8B:A7B:3C4D:0:6B
Compressed	FE80:C7B:F042:4D8B:A7B:3C4D::6B

III. Anycast Addresses: address assigned to several interfaces belonging to another unit. If we send a packet to an anycast address, it will be delivered to the closest host. Basically, several devices can be assigned with identical anycast address. We are using a routing protocol in the network that can determine which interface is physically closest and send it through the shortest path (Cisco, 2020).

Example (Figure1), we are assigning the same anycast address to those servers. The Packets we sent to that IP will be forwarded to the nearest server. We can use the phrase one to one of many address . Anycast addresses are used for balancing the load (Graziani, 2017).

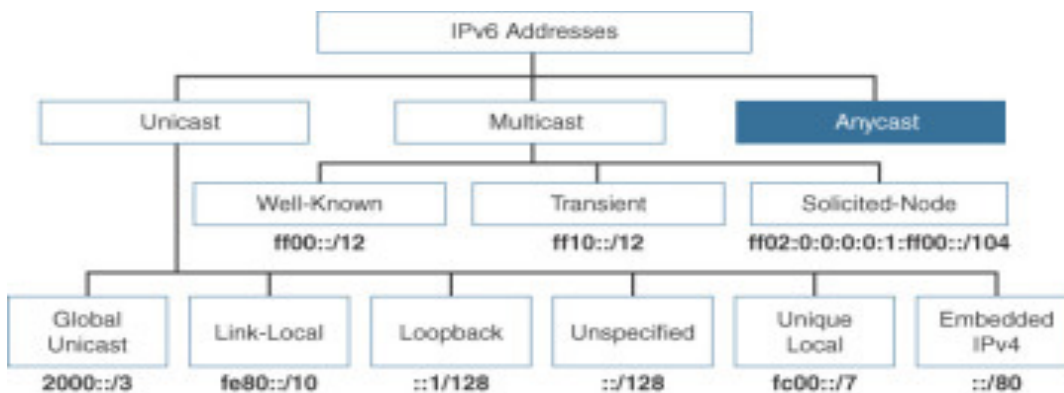


Figure1

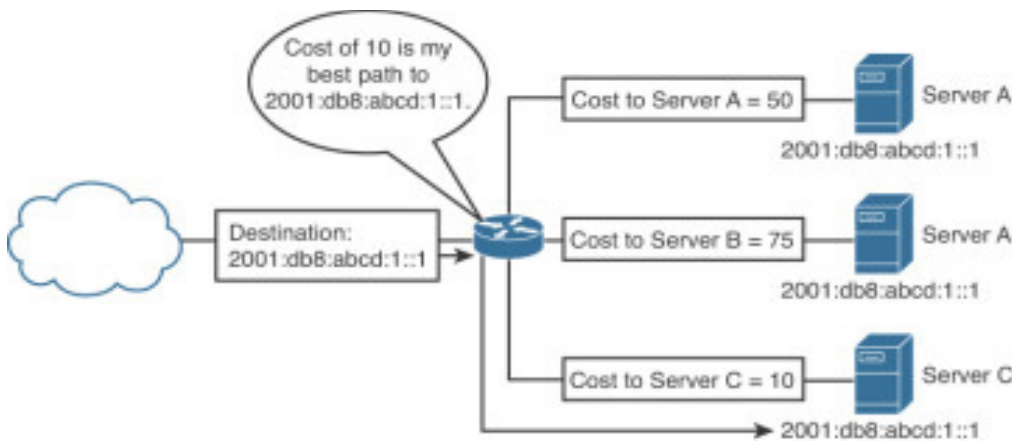


Figure2

Figure2: Example that servers A,B and C could be DHCPv6 server with a direct connection into the network. These servers could advertise the same /128 address. The nearest router (to the host) request will forward packets to the nearest server assigned in the routing table (Graziani, 2017).

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Addressing Table

Lab Number	Network address	First IPaddress	Last IPaddress	Broadcast address	Subnet mask
APPLIED COMP					
Open Access Lab 240H	172.16.0.0	172.16.0.1	172.16.0.254	172.16.0.255	255.255.255.0
Lab308 – 120H	172.16.1.0	172.16.1.1	172.16.1.126	172.16.1.127	255.255.255.128
Lab410 – 50H	172.16.1.128	172.16.1.129	172.16.1.190	172.16.1.191	255.255.255.192
Lab301 – 45H	172.16.1.192	172.16.1.193	172.16.1.254	172.16.1.255	255.255.255.192
Lab412 – 36H	172.16.2.0	172.16.2.1	172.16.2.62	172.16.2.63	255.255.255.192
Lab306 – 35H	172.16.2.64	172.16.2.65	172.16.2.126	172.16.2.127	255.255.255.192
Lab302 – 30H	172.16.2.128	172.16.2.129	172.16.2.190	172.16.2.191	255.255.255.192
Lab303 – 30H	172.16.2.192	172.16.2.193	172.16.2.254	172.16.2.255	255.255.255.192
Lab411 – 30H	172.16.3.0	172.16.3.1	172.16.3.62	172.16.3.63	255.255.255.192
Test Centre 29H	172.16.3.64	172.16.3.65	172.16.3.126	172.16.3.127	255.255.255.192
Staff room – 25H	172.16.3.128	172.16.3.129	172.16.3.190	172.16.3.191	255.255.255.192
Lab305 – 20H	172.16.3.192	172.16.3.193	172.16.3.254	172.16.3.255	255.255.255.192
	IPv6 Address		Prefix		Default Gateway
DNS	2001:DB6:1:1::2		/64		FE80::1
EMAIL	2001:DB6:1:1::3		/64		FE80::1
Registry	2001:DB6:1:1::4		/64		FE80::1
Files	2001:DB6:1:2::2		/64		FE80::1
Print	2001:DB6:1:2::3		/64		FE80::1
AUTO Engineer					
Lab301 – 85H	172.16.5.0	172.16.5.1	172.16.5.126	172.16.5.127	255.255.255.128
Lab206 – 55H	172.16.5.128	172.16.5.129	172.16.5.190	172.16.5.191	255.255.255.192
Lab102 – 35H	172.16.5.192	172.16.5.193	172.16.5.254	172.16.5.255	255.255.255.192
Lab103 – 30H	172.16.6.0	172.16.6.1	172.16.6.62	172.16.6.63	255.255.255.192
Lab101 – 25H	172.16.6.64	172.16.6.65	172.16.6.94	172.16.6.95	255.255.255.224
Lab205 – 20H	172.16.6.96	172.16.6.97	172.16.6.126	172.16.6.127	255.255.255.224
Staff – 20H	172.16.6.128	172.16.6.129	172.16.6.158	172.16.6.159	255.255.255.224
CAD Lab – 10H	172.16.6.160	172.16.6.161	172.16.6.188	172.16.6.189	255.255.255.224
Architecture					
Lab409 – 60H	172.16.8.0	172.16.8.1	172.16.8.126	172.16.8.127	255.255.255.192
Lab201 – 54H	172.16.8.128	172.16.8.129	172.16.8.190	172.16.8.191	255.255.255.192
Lab410 – 45H	172.16.8.192	172.16.8.193	172.16.8.254	172.16.8.255	255.255.255.192
Lab404 – 35H	172.16.9.0	172.16.9.1	172.16.9.62	172.16.9.63	255.255.255.192
Lab203 – 30H	172.16.9.64	172.16.9.65	172.16.9.126	172.16.9.127	255.255.255.192
Lab205 – 28H	172.16.9.128	172.16.9.129	172.16.9.190	172.16.9.191	255.255.255.192
Lab408 – 28H	172.16.9.192	172.16.9.193	172.16.9.254	172.16.9.255	255.255.255.192
Lab202 – 25H	172.16.10.0	172.16.10.1	172.16.10.62	172.16.10.63	255.255.255.224
IPv6 Address for link between MP and ISP:			FE80 : 0000 : 0000 : abcd : abcd : abcd : abcd		