

R-Pi

Team Emertxe



IoT Protocols

IPv6



IPv6

Introduction



- IPv6 is a new addressing protocol designed to incorporate all the possible requirements of future Internet known to us as Internet version 2.
- Its predecessor Ipv4 and works on the Network Layer (Layer-3).
- Along with its offering of an enormous amount of logical address space, this protocol has ample features to which address the shortcoming of IPv4.

IPv6

Introduction: Why new IP version

- Internet has grown exponentially and the address space allowed by IPv4 is saturating.
- There is a requirement to have a protocol that can satisfy the needs of future Internet addresses that is expected to grow in an unexpected manner.
- IPv4 on its own does not provide any security feature.
 - Data has to be encrypted with some other security application before being sent on the Internet.
- Data prioritization in IPv4 is not up to date. Though IPv4 has a few bits reserved for Type of Service or Quality of Service, but they do not provide much functionality.
- IPv4 enabled clients can be configured manually or they need some address configuration mechanism.
 - It does not have a mechanism to configure a device to have globally unique IP address.

Features



IPv6: Features

Larger Address Space



- In contrast to IPv4, IPv6 uses 4 times more bits to address a device on the Internet.
- This much of extra bits can provide approximately 3.4×10^{38} different combinations of addresses.
- This address can accumulate the aggressive requirement of address allotment for almost everything in this world.
- According to an estimate, 1564 addresses can be allocated to every square meter of this earth.

IPv6: Features

Simplified Header



- IPv6's header has been simplified by moving all unnecessary information and options to the end of the IPv6 header.
- IPv6 header is only twice as bigger than IPv4 provided the fact that IPv6 address is four times longer.

IPv6: Features

End-to-end Connectivity



- Every system now has unique IP address and can traverse through the Internet without using NAT or other translating components.
- After IPv6 is fully implemented, every host can directly reach other hosts on the Internet, with some limitations involved like Firewall, organization policies, etc.

IPv6: Features

Auto-configuration

- IPv6 supports both stateful and stateless auto configuration mode of its host devices.
- This way, absence of a DHCP server does not put a halt on inter segment communication.

IPv6: Features

Faster Forwarding/Routing



- Simplified header puts all unnecessary information at the end of the header.
- The information contained in the first part of the header is adequate for a Router to take routing decisions, thus making routing decision as quickly as looking at the mandatory header.

IPv6: Features

IPSec

- Initially it was decided that IPv6 must have IPSec security, making it more secure than IPv4.
- This feature has now been made optional.

IPv6: Features

No Broadcast

- Though Ethernet/Token Ring are considered as broadcast network because they support Broadcasting, IPv6 does not have any broadcast support any more.
- It uses multicast to communicate with multiple hosts.

IPv6: Features

Anycast Support



- This is another characteristic of IPv6.
- IPv6 has introduced Anycast mode of packet routing.
- In this mode, multiple interfaces over the Internet are assigned same Anycast IP address.
- Routers, while routing, send the packet to the nearest destination.

IPv6: Features

Mobility



- IPv6 was designed keeping mobility in mind.
- This feature enables hosts (such as mobile phone) to roam around in different geographical area and remain connected with the same IP address.
- The mobility feature of IPv6 takes advantage of auto IP configuration and Extension headers.

IPv6: Features

Enhanced Priority Support

- IPv4 used 6 bits DSCP (Differential Service Code Point) and 2 bits ECN (Explicit Congestion Notification) to provide Quality of Service but it could only be used if the end-to-end devices support it, that is, the source and destination device and underlying network must support it.
- In IPv6, Traffic class and Flow label are used to tell the underlying routers how to efficiently process the packet and route it.

IPv6: Features

Smooth Transition



- Large IP address scheme in IPv6 enables to allocate devices with globally unique IP addresses.
- This mechanism saves IP addresses and NAT is not required.
- So devices can send/receive data among each other, for example, VoIP and/or any streaming media can be used much efficiently.
- Other fact is, the header is less loaded, so routers can take forwarding decisions and forward them as quickly as they arrive.

IPv6: Features

Extensibility



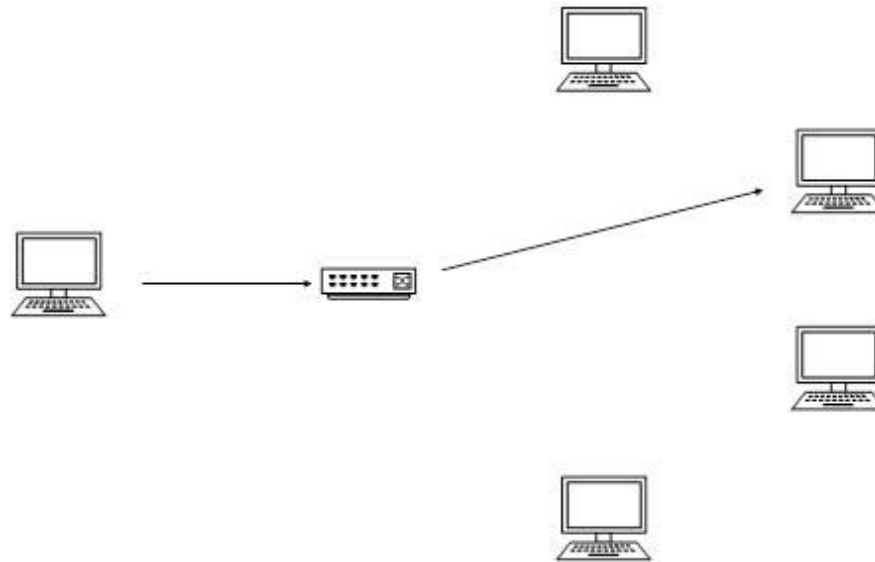
- One of the major advantages of IPv6 header is that it is extensible to add more information in the option part.
- IPv4 provides only 40-bytes for options, whereas options in IPv6 can be as much as the size of IPv6 packet itself.

Addressing Modes



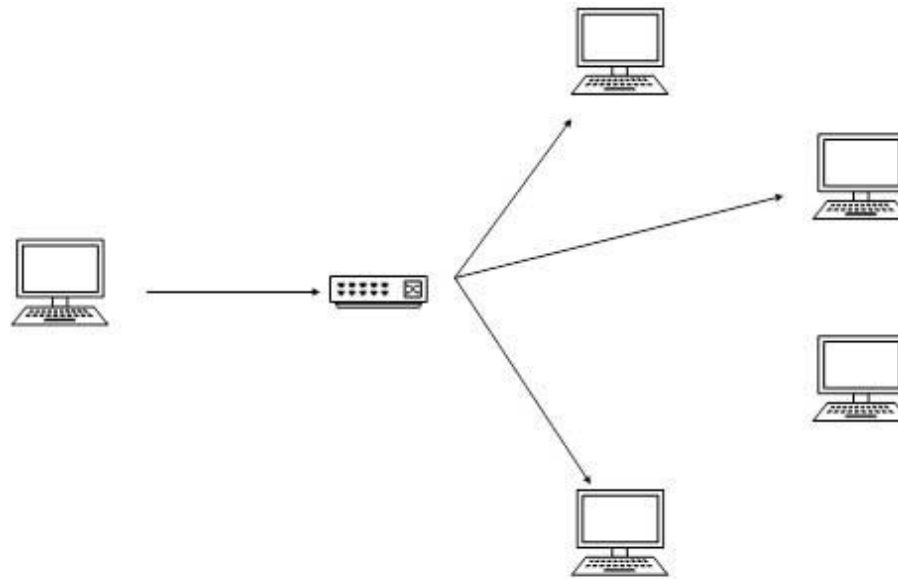
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Unicast Addressing Mode



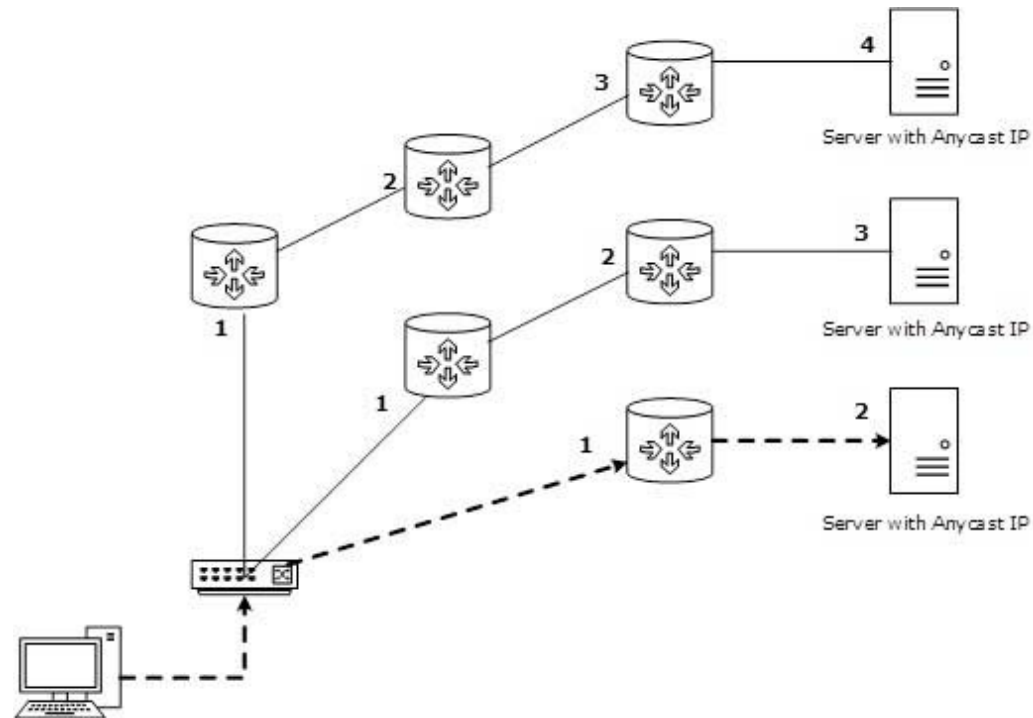
IPv4

Multicast Addressing Mode



IPv4

Anycast Addressing Mode



Addressing Types



IPv6

Address Structure



- An IPv6 address is made of 128 bits divided into eight 16-bits blocks.
- Each block is then converted into 4-digit Hexadecimal numbers separated by colon symbols.
- For example, given below is a 128 bit IPv6 address represented in binary format and divided into eight 16-bits blocks:

```
0010000000000001 0000000000000000 0011001000111000 1101111111100001  
0000000001100011 0000000000000000 0000000000000000 1111111011111011
```

- Each block is then converted into Hexadecimal and separated by ':' symbol:

2001:0000:3238:DFE1:0063:0000:0000:FEFB
- Even after converting into Hexadecimal format, IPv6 address remains long.
- IPv6 provides some rules to shorten the address.

IPv6

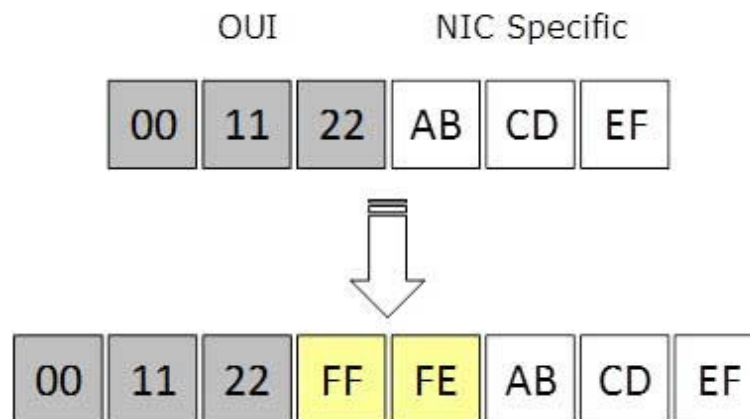
Address Structure: Rules

- Rule-1: Discard leading Zero(es): In Block 5, 0063, the leading two 0s can be omitted, such as (5th block):
 - 2001:0000:3238:DFE1:63:0000:0000:FEFB
- Rule.2: If two or more blocks contain consecutive zeroes, omit them all and replace with double colon sign ::, such as (6th and 7th block):
 - 2001:0000:3238:DFE1:63::FEFB
- Consecutive blocks of zeroes can be replaced only once by :: so if there are still blocks of zeroes in the address, they can be shrunk down to a single zero, such as (2nd block):
 - 2001:0:3238:DFE1:63::FEFB

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Interface ID

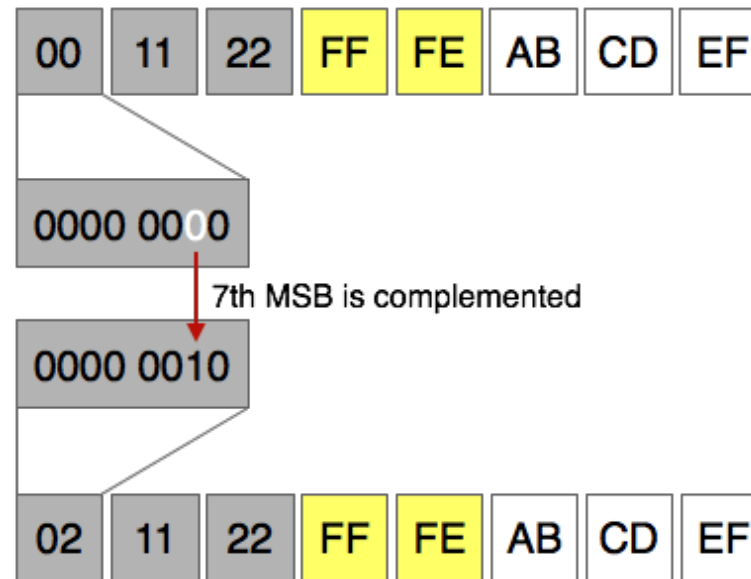
- IPv6 has three different types of Unicast Address scheme.
- The second half of the address (last 64 bits) is always used for Interface ID.
- The MAC address of a system is composed of 48-bits and represented in Hexadecimal.
- MAC addresses are considered to be uniquely assigned worldwide.
- Interface ID takes advantage of this uniqueness of MAC addresses.
- A host can auto-configure its Interface ID by using IEEE's Extended Unique Identifier (EUI-64) format.
- First, a host divides its own MAC address into two 24-bits halves.
- Then 16-bit Hex value 0xFFFFE is sandwiched into those two halves of MAC address, resulting in EUI-64 Interface ID.



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Interface ID

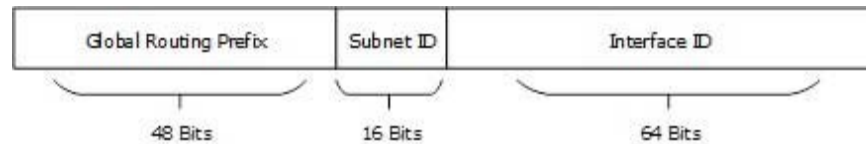
- Conversion of EUI-64 ID into IPv6 Interface Identifier
- To convert EUI-64 ID into IPv6 Interface Identifier, the most significant 7th bit of EUI-64 ID is complemented



IPv6

Global Unicast Address

- This address type is equivalent to IPv4's public address.
- Global Unicast addresses in IPv6 are globally identifiable and uniquely addressable.



- Global Routing Prefix:
 - The most significant 48-bits are designated as Global Routing Prefix which is assigned to specific autonomous system.
 - The three most significant bits of Global Routing Prefix is always set to 001.

IPv6

Link-Local Address

- Auto-configured IPv6 address is known as Link-Local address.
- This address always starts with FE80.
- The first 16 bits of link-local address is always set to 1111 1110 1000 0000 (FE80).
- The next 48-bits are set to 0, thus:

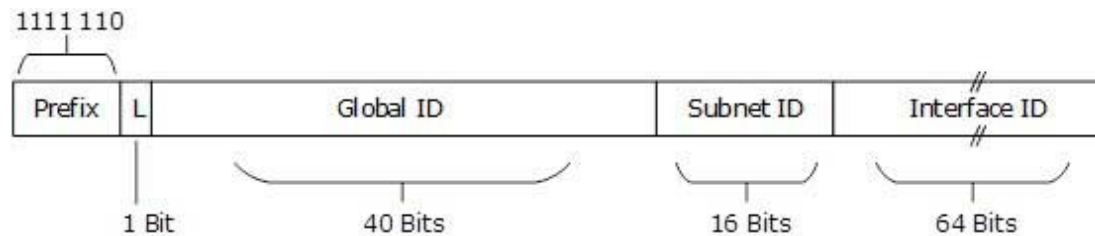


- Link-local addresses are used for communication among IPv6 hosts on a link (broadcast segment) only.
- These addresses are not routable, so a Router never forwards these addresses outside the link.

IPv6

Unique-Local Address

- This type of IPv6 address is globally unique, but it should be used in local communication.
- The second half of this address contains Interface ID and the first half is divided among Prefix, Local Bit, Global ID and Subnet ID.

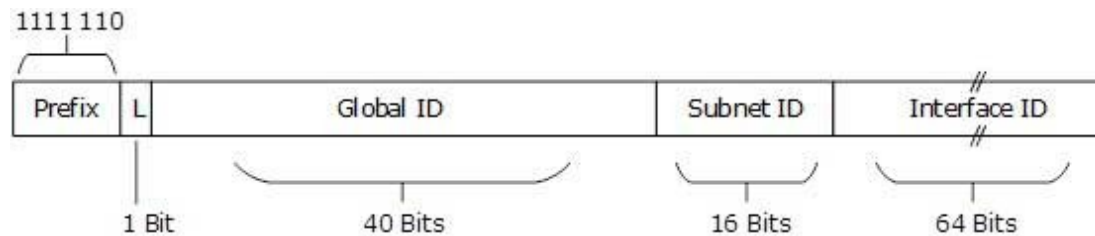


- Prefix is always set to 1111 110.
- L bit, is set to 1 if the address is locally assigned.
- So far, the meaning of L bit to 0 is not defined.
- Therefore, Unique Local IPv6 address always starts with 'FD'.

IPv6

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Headers

IPv6

Fixed Header

	4-11		12-31		
0-3	Version	Traffic Class	Flow Label		
32-47	Payload Length		48-55 Next Header	Hop Limit	56-63
64-191	Source Address				
192-288	Destination Address				

Communication



IPv6

Communication



- In IPv6, there are no broadcast mechanisms.
- It is not a must for an IPv6 enabled host to obtain an IP address from DHCP or manually configured, but it can auto-configure its own IP.
- ARP has been replaced by ICMPv6 Neighbor Discovery Protocol.

IPv6

Neighbor Discovery Protocol

- A host in IPv6 network is capable of auto-configuring itself with a unique link-local address.
- As soon as host gets an IPv6 address, it joins a number of multicast groups.
- All communications related to that segment take place on those multicast addresses only.
- A host goes through a series of states in Ipv6:
 - Neighbor Solicitation
 - DAD (Duplicate Address Detection)
 - Neighbor Advertisement

IPv6

Neighbor Discovery Protocol

- Once a host is done with the configuration of its IPv6 addresses, it does the following things
 - Router Solicitation
 - Router Advertisement
 - Redirect

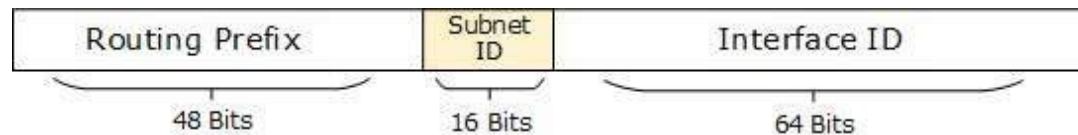
Subnetting



IPv6

Subnetting

- IPv6 addresses use 128 bits to represent an address which includes bits to be used for subnetting.
- The second half of the address (least significant 64 bits) is always used for hosts only.
- Therefore, there is no compromise if we subnet the network.



- 16 bits of subnet is equivalent to IPv4's Class B Network.
- Using these subnet bits, an organization can have another 65 thousands of subnets which is by far, more than enough.

IPv6

Subnetting

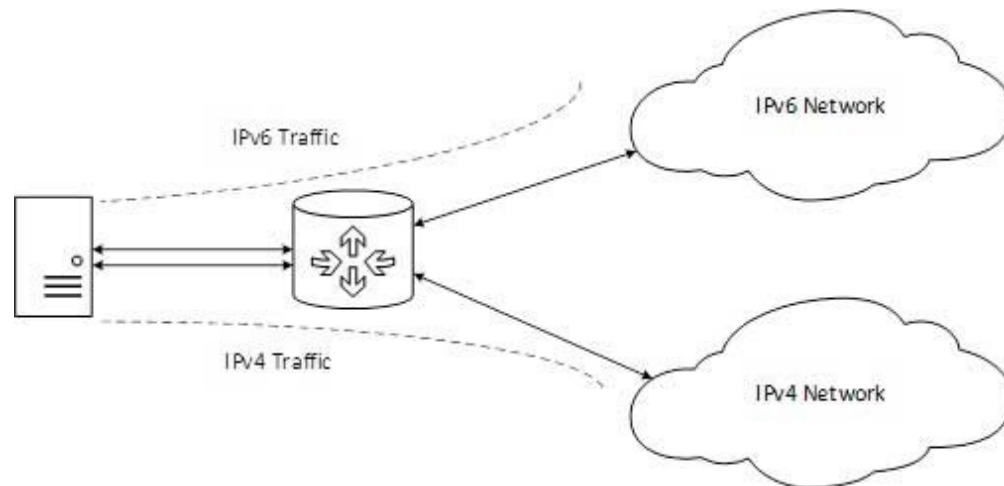
- Thus routing prefix is /64 and host portion is 64 bits.
- We can further subnet the network beyond 16 bits of Subnet ID, by borrowing host bits; but it is recommended that 64 bits should always be used for hosts addresses because auto-configuration requires 64 bits.
- IPv6 subnetting works on the same concept as Variable Length Subnet Masking in IPv4.
- /48 prefix can be allocated to an organization providing it the benefit of having up to /64 subnet prefixes, which is 65535 sub-networks, each having 264 hosts.
- A /64 prefix can be assigned to a point-to-point connection where there are only two hosts (or IPv6 enabled devices) on a link.

Ipv4 -> IPv6



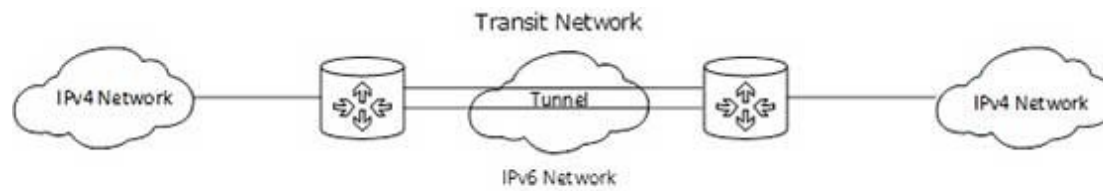
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Dual Stack Routers



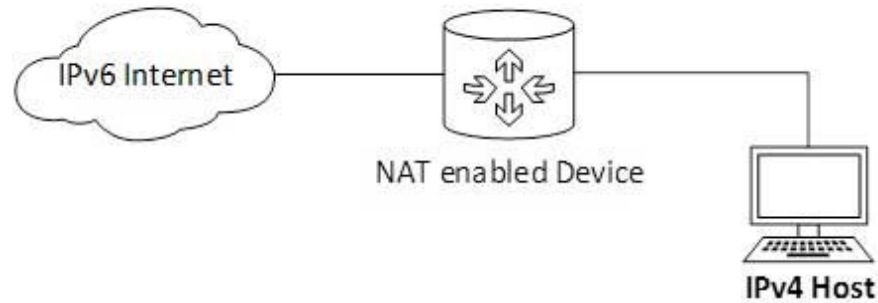
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Tunneling



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NAT Protocol Translation



THANK YOU