IPv6

Introduction

- Internet Protocol version 6, is a new addressing protocol
- It is 128 bits unlike IPv4 which is 32 bits hence it has very many IP addresses
- Along with its offering of enormous amount of logical address space, this protocol has ample of features which addresses today's shortcoming of IPv4.

Why IPv6

- So far, IPv4 has proven itself as a robust routable addressing protocol and has served human being for decades on its best-effort-delivery mechanism.
- It was designed in early 80's and did not get any major change afterward.
- At the time of its birth, Internet was limited only to a few Universities for their research and to Department of Defense.
- IPv4 is 32 bits long which offers around 4,294,967,296 (2^{32}) addresses.
- This address space was considered more than enough that time.

Why IPv6

- Given below are major points which played key role in birth of IPv6:
  a) Internet has grown exponentially and the address space allowed by IPv4 is saturating. There is a requirement of protocol which can satisfy the need of future Internet addresses which are expected to grow in an unexpected manner.
  b) Using features such as NAT due to the inadequate number of IPv4 addresses , has made the Internet discontiguous i.e. one part which belongs to intranet, primarily uses private IP addresses; which has to go through number of mechanism to reach the other part, the Internet, which is on public IP addresses.
  c) IPv4 on its own does not provide any security feature which is vulnerable as data on Internet, which is a public domain, is never safe. Data has to be encrypted with some other security application before being sent on Internet.
  d) IPv4 enabled clients have be configured manually or they need some address configuration mechanism. There exists no technique which can configure a device to have globally unique IP address.

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^{38} different combinations of addresses.
  - This address can accumulate the aggressive requirement of address allotment for almost everything in this world.
- **Simplified Header:**
  - IPv6's header has been simplified by moving all unnecessary information and options (which are present in IPv4 header) to the end of the IPv6 header.
  - IPv6 header is only twice as bigger than IPv4 (32 bits) providing the fact the IPv6 (128 bits) address is four times longer.

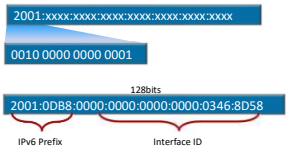
IPv6 Features

- **End-to-end Connectivity**:
  - Every host/device/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 host on the Internet, with some limitations involved like Firewall, Organization's policies, etc.
- **Faster Forwarding/Routing**:
  - Simplified header puts all unnecessary information at the end of the header.
  - All information in first part of the header are adequate for a router to take routing decision thus making routing decision as quickly as looking at the mandatory header, unlike IPv4 addresses.

IPv6 Features

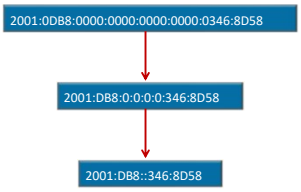
- **IPSec**:
  - IPv6 has IPSec security incorporated, making it more secure than IPv4.
  - IPsec has authentication and encryption features
- **No Broadcast**:
  - IPv6 does not have any broadcast support anymore left with it.
  - It uses multicast to communicate with multiple hosts.

IPv6 Address Architecture



- Addresses are commonly displayed in hexadecimal format.
- IPv6 address consists of a prefix and an interface identifier.
- Prefix – Network portion of IP address, similar to subnet mask
- Interface identifier - Identifies a host

IPv6 Address Condensing



- Addresses can be condensed by removing the leading zeroes.
- The :: operator will further condense strings of zero values.
- In order to enable the string size to be determinable however, the "::" can only appear once in an address.
- The double colon "::" can be used to compress leading zeros in an address as displayed in the given example.

Types of IPv6 Addresses

- **No broadcast in IPv6**
- **Unicast Address**:
  - Packets addressed to a unicast address is destined for a single interface.
  - This can also referred to as one –to-one Ipv6 address.
  - Different type of unicast addressing are:
    - **Global Unicast Address:** An IPv6 unicast address is globally routable on the public internet.
    - **Link-local Addresses:** These are private address that is not meant to be routed on the internet. They can be used locally by private or temporary LANs for sharing and distribution of file among devices on the LAN.

Types of IPv6 Addresses

- **Multicast Address:**
  - This can also be referred to as One-to-Many.
  - Packets addressed to multicast address are delivered to all interface identified by the multicast address.
  - Multicast address types are easily notable because they normally begins with FF.
- **Anycast:**
  - This form of IPv6 address is similar to the multicast address with a slight difference.
  - Anycast address can also be referred to as One to Nearest.
  - It can be used to address packets meant for multiple interfaces; but usually it sends packets to the first interface it finds as defined in the routing distance.
  - This means it send packets to the closest interface as determined by routing protocols.
- **Loopback Address:** The loopback address is 0:0:0:0:0:0:0:1, which is normally expressed using zero compression as "**::1**".

IPv6 Address Reservations

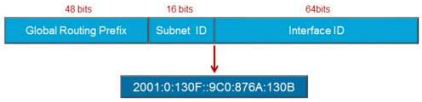
Address Range	Description
2000::/3	Current Global Unicast Range
2001:0DB8::/32	Reserved for Documentation
FE80::/10	Link Local Unicast Address Range
FF00::/8	Multicast Address Range
::/128	Unspecified Address
::1/128	Loopback Address

- Address ranges have been allocated in IPv6 for unicast and multicast, along with special addresses for operational support.

IPv6 Address Reservations

- Multicast addressing is defined within IPv6 as FF00::/8,
- ::/128 - represents an interface for which there is no IP address currently assigned.
- ::/0 - used as a default address value for any network in the same way the 0.0.0.0/0 default address is used within IPv4.
- For the **loopback address (127.0.0.1),** this is defined in IPv6 as the reserved address ::1/128.

IPv6 Addressing – Global Unicast



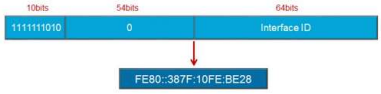
- Global Unicast addresses in IPv6 are globally identifiable and uniquely addressable.
- Global unicast address prefixes are used for public networks.
- Global Routing Prefix: The most significant 48-bits are designated as Global Routing Prefix which is assigned to specific autonomous system.
- The three most significant bits of Global Routing Prefix is always set to 001

IPv6 Addressing – Global Unicast

- The global routing prefix is designed to be structured hierarchically by the Regional Internet Registries (RIR) and the Internet Service Providers (ISP) to whom the RIR distribute IP address prefixes. E.g AFRINIC in Africa, APNIC in Asia
- The subnet field is designed to be structured hierarchically by site administrators to provide up to 65535 individual subnets.

IPv6 Addressing – Link Local Unicast

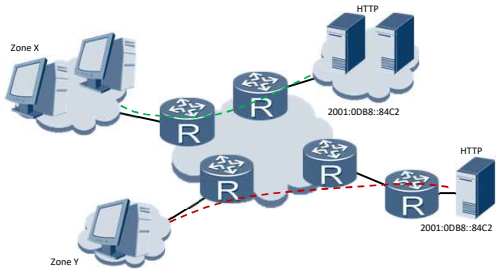
- In terms of the Link Local unicast address, the FE80::/10 means that the first 10 bits of the link local address is clearly distinguishable as 1111111010.
- The 64-bit interface address range is more than sufficient for the addressing of hosts, and therefore the remaining 54bits within the Link Local address are maintained as 0.



IPv6 Addressing – Multicast

- Multicast addresses are distinguished by an FF00::/8 prefix.

IPv6 Addressing – Anycast

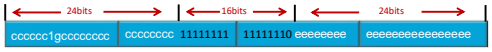


- Anycast allows multiple instances of a service to be associated with a single address, enabling a variety of service applications.

EUI-64 for IP Address Auto-configuration

48-bit MAC address

EUI-64 generated interface ID



- A host MAC address is injected with 16 bit 'FF' 'FE' values to generate a 64-bit interface identifier for the IPv6 address.

EUI-64 for IP Address Auto-configuration

- IEEE EUI-64 standards use the interface MAC address to generate an IPv6 interface ID.
- The MAC address however represents a 48-bit address whilst the required interface ID must be composed of a 64-bit value.
- The first 24 bits (expressed by c) of the MAC address represent the vendor (company) ID, while the remaining 24 bits (expressed by e) represents the unique extension identifier assigned by the manufacturer.
- During conversion, the EUI-64 process inserts two octet "0xFF" and "0xFE" values totaling 16 bits between the vendor identifier and extension identifier of the MAC address, and the universal/local bit 0 is changed to 1 to indicate that the interface ID now represents a globally unique address value.