TRINITY INTERNATIONAL COLLEGE

(Tribhuvan University Affiliated)

Assignment 1:
Advance Networking with IPv6

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1. **Explain the history of IPv6 and addressing of IPv6.**

Internet Protocol Version 4 (IPv4) was the first publicly used version of the Internet Protocol. IPv4 was developed as a research project by the Defense Advanced Research Projects Agency (DARPA), a United States Department of Defense agency, before becoming the foundation for the Internet and the World Wide Web. IPv4 includes an addressing system that uses numerical identifiers consisting of 32 bits. These addresses are typically displayed in quad-dotted notation as decimal values of four octets, each in the range 0 to 255, or 8 bits per number. Thus, IPv4 provides an addressing capability of 232 or approximately 4.3 billion addresses. Address exhaustion was not initially a concern in IPv4 as this version was originally presumed to be a test of DARPA's networking concepts. During the first decade of operation of the Internet, it became apparent that methods had to be developed to conserve address space.In the early 1990s, even after the redesign of the addressing system using a classless network model, it became clear that this would not suffice to prevent IPv4 address exhaustion, and that further changes to the Internet infrastructure were needed. The last unassigned top-level address blocks of 16 million IPv4 addresses were allocated in February 2011 by the Internet Assigned Numbers Authority (IANA) to the five regional Internet registries (RIRs). However, each RIR still has available address pools and is expected to continue with standard address allocation policies until one /8 Classless Inter-Domain Routing (CIDR) block remains.After that, only blocks of 1024 addresses (/22) will be provided from the RIRs to a local Internet registry (LIR). As of September 2015, all of Asia-Pacific Network Information Centre (APNIC), the Réseaux IP Européens Network Coordination Centre (RIPE_NCC), Latin America and Caribbean Network Information Centre (LACNIC), and American Registry for Internet Numbers (ARIN) have reached this stage. This leaves African Network Information Center (AFRINIC) as the sole regional internet registry that is still using the normal protocol for distributing IPv4 addresses. As of November 2018, AFRINIC's minimum allocation is /22 or 1024 IPv4 addresses. A LIR may receive additional allocation when about 80% of all the address space has been utilized. It is widely expected that the Internet will use IPv4 alongside IPv6 for the foreseeable future. Direct communication between the IPv4 and IPv6 network protocols is not possible.

- The Internet Engineering Task Force (IETF) began the effort to develop a successor protocol to IPv4 in the early 1990s.
- The IETF started the Internet Protocol—Next Generation (IPng) area in 1993 to investigate the different proposals and to make recommendations for further procedures
- The IPng area directors of the IETF recommended the creation of IPv6 at the Toronto IETF

meeting in 1994

 In 1994, the ALE (Address Lifetime Expectation) working group projected that the IPv4 address exhaustion would occur sometime between 2005 and 2011 based on the available statistics.

 The Internet Engineering Steering Group approved the IPv6 recommendation and drafted a Proposed Standard on November 17, 1994

 RFC 1883, "Internet Protocol, Version 6 (IPv6) Specification," was published in 1995.

 The core set of IPv6 protocols became an IETF Draft Standard on August 10, 1998. This included RFC 2460, which obsoleted RFC 1883.

 2003 – RFC 2553 – Basic Socket API

 2003 – RFC 3315 – DHCPv6

 2004 – RFC 3775 – Mobile IPv6

 2004 – RFC 3697 – Flow Label Specification

 2006 – RFC 4291 – Address architecture (revision)

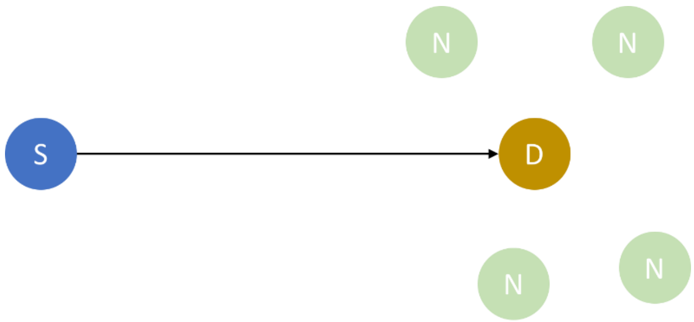
 2006 – RFC 4294 – Node requirement

Addressing of IPv6

In computer networking, addressing mode refers to the mechanism of hosting an address on the network. IPv6 offers several types of modes by which a single host can be addressed. More than one host can be addressed at once or the host at the closest distance can be addressed.

- Unicast

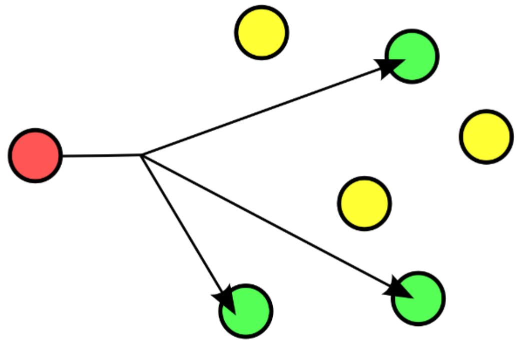
  In unicast mode of addressing, an IPv6 interface (host) is uniquely identified in a network segment. The IPv6 packet contains both source and destination IP addresses. A host interface is equipped with an IP address which is unique in that network segment. When a network switch or a router receives a unicast IP packet, destined to a single host, it sends out one of its outgoing interface which connects to that particular host.



Unicast

- Multicast

The IPv6 multicast mode is same as that of IPv4. The packet destined to multiple hosts is sent on a special multicast address. All the hosts interested in that multicast information, need to join that multicast group first. All the interfaces that joined the group receive the multicast packet and process it, while other hosts not interested in multicast packets ignore the multicast information.



- Anycast

IPv6 has introduced a new type of addressing, which is called anycast addressing. In this addressing mode, multiple interfaces (hosts) are assigned same anycast IP address. When a host wishes to communicate with a host equipped with an anycast IP address, it sends a Unicast message. With the help of complex routing mechanism, that Unicast message is delivered to the host closest to the Sender in terms of Routing cost.

2. Explain the feature of IPv6 and its addressing.

- 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.

- 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 provided the fact that IPv6 address is four times longer.

- 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.

- 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.

- 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.

- IPSec

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

- 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

- 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.

- 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.

- 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.

- 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.

- 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:

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 0xFFFE is sandwiched into those two halves of MAC address, resulting in EUI-64 Interface ID.

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. Start with 2000::/3 (the first three bits 001) assigned by IANA

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. The router do not forward packets with link-local addresses. (FE80::/10) 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.

Unique-Local Address

Like private ip and they are not routable in the global IPV6 internet. This type of IPv6 address is globally unique, but it should be used in local communication. The second half of this address contain 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 ‘FC00’ or ‘FD00’. (FC00::/7)

3. Explain the IPv6 and its feature.

With the ever-increasing number of new devices being connected to the Internet, the need arose for more addresses than the IPv4 address space has available. IPv6 uses a 128-bit address, allowing 2^128, or approximately 3.4×10^38 addresses, or more than 7.9×10^28 times as many as IPv4, which uses 32-bit addresses. Scalability and flexibility have been extended. IPv6 is a protocol designed to handle the growth rate of the Internet and to cope with the demanding requirements on services, mobility, and end-to-end security. There is still work to be done to reach parity with the maturity of IPv4. The missing pieces of IPv6 will be developed in the coming years, just the way it happened with IPv4

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