

Internet Protocol (IP): Version 6 (IPv6)

IPv6 was devised in 1995 to fix problems with IPv4, including primarily the address space.

Addresses are comprised of 16 octets (8-bit bytes). Hence, an IPv6 address has 128 bits.

$2^{128} = 340,282,366,920,938,463,463,374,607,431,768,211,456$ possible addresses

"The earth is about 4.5 billion years old. If we had been assigning IPv6 addresses at a rate of 1 billion per second since the earth was formed, we would have by now used up less than one trillionth of the address space....The earth's surface area is about 510 trillion square meters. If a typical computer has a footprint of about a tenth of a square meter, we would have to stack computers 10 billion high blanketing the entire surface of the earth to use up that same trillionth of the address space." (Source: "IPv6 Address Size and Address Space", retrieved Oct. 22, 2017, from http://www.tcpipguide.com/free/t_IPv6AddressSizeandAddressSpace-2.htm)

IPv6 addresses are expressed in hexadecimal in order to shorten them.

Additionally, using hexadecimal makes it easier to convert these addresses to binary.

Each address is subdivided into eight (8) two-byte values, each being expressed with four hexadecimal digits.

The two-byte values are separated by colons (:), rather than periods (.), which are used in IPv4. Example:

805B:2D9D:DC28:0000:0000:FC57:D4C8:1FFF

An IPv6 address can also contain an IPv4 address, embedded as the last 4 bytes. This is known as mixed notation. Example:

805B:2D9D:DC28::FC57:212.200.31.255

Mixed notation is used for communicating between devices that use different versions of IP.

The first 64 bits of the address is the network prefix, while the last 64 bits comprise the interface identifier.

Because of its size, an IPv6 address can be the combination of the network prefix and the MAC address; hence, hosts can configure their own IPv6 addresses.

Header

- IPv6 relies of a single main header and additional, optional headers.
- The main header is 40 bytes long, but is greatly simplified (http://www.tcpipguide.com/free/t_IPv6DatagramMainHeaderFormat.htm)

Some important changes from IPv4

- IPv6 addresses are 128 bits long instead of 32 bits. This expands the address space from around 4 billion addresses to an astronomical number (over 300 trillion trillion trillion addresses).
- It permits generating IP addresses based on underlying hardware interface device IDs such as Ethernet MAC addresses. Hence, hosts can autoconfigure themselves, and IP addresses in networks and subnetworks can be renumbered as needed. A technique also exists for renumbering router addresses.
- The IPv6 protocol is designed to support modern routing systems, and to allow expansion as the Internet grows.
- Fragmentation support is relegated to the source host, which is permitted to discover the MTU for the path to the destination host; routers are not permitted to fragment.