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Student Name: Yuan Fang
Student ID: 0046543

IPv6

Introduction

IPv6, Internet Protocol Version 6, is the next generation of the TCP/IP protocol suite. IPv6 has been designed to replace IPv4, and upgrading computer networks to this newer protocol will represent a massive technological undertaking in the coming years and decades.

IPv4 has been nearly unchanged for more than 30 years since this protocol suite was first established in the early 1970s. Over these 30 years, IPv4 has been proven to be remarkably resilient, and has not required any substantial changes. Yet, as the global Internet continues to grow at an exponential rate due to the introduction of IP-enabled mobile devices, there is a burning need for a larger address space. The limited 32-bit IP address space of IPv4 will soon become an insurmountable obstacle to the growth of the global Internet. At the same time, the introduction of IPv6 provides the opportunity to introduce new features that will make the IP protocol better suited for real-time applications and secure electronic commerce.

Features of IPv6

Larger Address Space: the new SOURCE ADDRESS and DESTINATION ADDRESS fields are 16-octets each, which is 4 times the size of an IPv4 address field. The new address space is so massive that everyone on the planet can have there own internet the same size as the current internet.

Extended Address Hierarchy: For IPv4 datagrams, the address structure can be analyzed as a two level hierarchy: subnet and interface. Because of the large address space of IPv6, it allows higher level address hierarchies: provider of the address, subnet and interface.

Extensive Header Format: instead of one fixed header, IPv6 datagram introduces the protocol header chain. It contains a fixed Base Header and a number of optional Extension Headers. This feature enables maximum usage of the datagram.

Autoconfiguration and Renumbering: IPv6 allows computers in isolated networks to assign themselves addresses instead of requiring manual configuration by an administrator. It also allows networks to be renumbered dynamically.

IPv6 Datagram Structure

As well as the enhanced address space, IPv6 has many features that enhance it over IPv4. They are directly tied to the form of the protocol. IPv6 almost completely changes the format of IPv4. The general form of IPv6 contains 3 main parts: Base Header, Extension Headers (optional), and Data, whereas IPv4 datagram contains only the standard header and data.

Base Header	Extension Header 1	…….	Extension Header N	Data…

Believe it or not, IPv6's Base Header (40-octets) actually contains less information than IPv4 standard header (20-octets). It moves some of the options and fixed fields of IPv4 header into the extension headers which are optional. This customizes and saves the space of unnecessary information in the datagram. The main differences between IPv6 base header and IPv4 header are:

1. Alignment has been changed from 32-bit to 64-bit multiples.
2. There is no more HLEN (header length) field in the datagram.
3. The TOTAL LENGTH field is replaced by the PAYLOAD LENGTH field which indicates the total number of octets contained in the datagram (excluding the header itself).
4. The SOURCE ADDRESS and DESTINATION ADDRESS fields specify the sender and the receiver, and continue to be used in the new datagram. However, the size of these fields have been expanded from 4 octets to 16 octets. This change allows for the larger capacity of the INTERNET.
5. Fragmentation is still allowed in the IPv6 protocol, but it is no longer a fixed field. It is now one of the optional Extension Headers.
6. In IPv4 datagrams, the TIME TO LIVE field interprets a combination of maximum number of hops and maximum time. For the updated datagram, it is replaced by HOP LIMIT field which indicates the maximum number of hops a datagram can pass before being discarded.
7. The SERVICE CLASS field found in IPv4 has been renamed as TRAFFIC CLASS and extended with the FLOW LABEL field. This is a new mechanism of IPv6 which supports resource reservation and allows a router to associate each datagram with a given resource allocation.
8. The PROTOCOL field is replaced by the NEXT HEADER field to specify the type of the next header (Extended Header).

The Base Header provides the basic information carried in an IPv6 datagram.

The most significant change in IPv6 is the extendable headers. The Base Header of IPv6 is followed by a flexible number of Extension Headers. These headers are very similar to the option fields in the IPv4 protocol, providing specific functionalities and mechanisms to be carried in a datagram. Including all the mechanisms in a fixed datagram header is inefficient because most datagrams require

only a fraction of the available mechanisms. When transferring a datagram using IPv4 protocol, empty fields often take up a large portion of a frame. IPv6 gets rid of the unnecessary header fields, and is therefore much more efficient and maximizes the usage of the datagram. This feature also allows the IETF to adapt the protocol to changes easily.

Current Support for IPv6

Although experts predict that it will take until at least 2010 for IPv6 to become the dominant protocol of the Internet, major operating system manufacturers and network equipment providers have already started to support IPv6 in their products. System designers face the challenge of having to create products that will work in a heterogeneous environment where some external devices will work with only IPv4, some will work with only IPv6, while others will work with both protocols. Two major strategies have been applied in operating system design to meet this requirement: the dual stack solution and the integrated stack. The dual stack solution, which is used in Microsoft Windows XP and Windows Server 2003, contains two separate implementations of the IP stack, one for IPv4 and one for IPv6. These stacks can be run independently at the same time. The integrated stack solution implements a single IP stack that has the flexibility of being able to interpret either protocol; this is the solution that has been implemented by operating systems such as Sun Solaris, Linux, and FreeBSD Unix. The dual stack solution is simpler to implement, but has a fairly steep price in terms of additional CPU and memory consumption.

Conclusion

IPv6 is the IETF's solution to the limited address space of IPv4. By the year 2010 it is expected to be the dominant protocol for the global Internet, and so it is important for engineers and software developers to be familiar with this important technology. One of the main differences between IPv4 and IPv6 is radically redesigned datagram structure, with a key feature being the introduction of a flexible, efficient, and extensible header structure. Large corporations have already started to role out products that have implementations of IPv6 technology, but they face the unique challenge of having to support two protocols at the same time while the world gradually transitions to the new protocol. Inevitably, the IPv6 protocol will come to dominate the networked world, and the Internet shall move forward into a new era after three decades under the stewardship of IPv4.