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Some aspects regarding the Internet protocol next generation

Adriana Diaconescu

Abstract. This paper presents some different ideas and opinions about the new version of Internet Protocol (IP) – **IPng**, also known as **IPv6**. IPng is designed as an evolutionary upgrade to the Internet Protocol and will, in fact, coexist with the older IPv4 for some time. This paper also reviews the features of the IPv6 protocol, the transition between today's IPv4 Internet and a future IPv6-based one, the structure of an IPv6 packet, the IPv6 header.

1. Introduction and Definition

With the rapid growth of the Internet and mobile telecommunication, and the convergence of technology and services, more and more devices are being connected with the IP protocol and there will be a need for more addresses then are currently available.

TCP/IP version 4 (IPv4) is probably the most used protocol in all networks and in the Internet (it was developed almost 30 years ago). It has proven over the years to be robust, stable, expandable, and reliable – everyone who checks their email or surfs a Web site uses IPv4. Still, work began on a successor protocol – it was called IPng (next generation) at that time. The main reason for working on a new protocol was the expected IP address exhaustion. This is the reason why many people think that if they currently have enough IPv4 addresses, there is no need to think about IPv6. Additionally, there were developed technologies like Network Address Translation (NAT) and Classless Interdomain Routing (CIDR) – to delay the address-space issues.

IPng – ***I****nternet* ***P****rotocol* ***n****ext* ***g****eneration* – is a new version of IP, reviewed in IETF standards (***I****nternet* ***E****ngineering* ***T****ask* ***F****orce*). The official name for **IPng** is ***IPv6***, where *v*6 means *version 6*. The current IP version is version 4, namely *IPv4*.

IPng is designed as an IP improvement and will coexist for some time with the older version IPv4. IPng is also designed to enable the constant increase of the Internet.

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IPv6 solves unanticipated IPv4 design issues, such as the limited address number. Also, it brings many other improvements on IPv4, in areas like routing and network autoconfiguration.

Like all new technologies, IPv6 raises questions, covering a broad range of subjects – technical aspects, technological benefits, strategy and deployment costs.

Predicting what will be the exact evolution of the use of IPv4 addresses is difficult. However it is possible to come up with tendencies by considering: the use of addresses to the present day, the potential increase in number of users, the technologies that could increase needs. This reasoning must also take into consideration the extremely unequal distribution of these addresses in the world.

The theoretical IPv4 address space is not completely used – RFC 3194: *The Host-Density Ratio for Address Assignment Efficiency: An update on the H ratio* – demonstrates that the number of addresses actually used is very low compared with the theoretical number of addresses.

This fact is sustained by other papers too: *IPv4 has run out of addresses* – this is in the category of myth rather than reality. Of the total IPv4 space, some 6% is reserved and another 6% is used for multicast. 41% of the space has already been allocated, and the remaining 37% (or some 1.5 billion addresses) is yet to be allocated. Prior to 1994 some 36% of the address space has been allocated. Since that time, and this includes the entire Internet boom period, a further 15% of the available address space was allocated. With a continuation of current policies it would appear that IPv4 address space will be available for many years yet.

We could mention here more points of view, which support the new protocol version IPv6:

✓ People who say there are enough IPv4 addresses are the ones who have big allocations. The government, universities, and organizations in the U.S. alone hold approximately 74% of the total IPv4 address space. One example: a provider of IP network services based in the U.S., has three Class A addresses – that amounts to approximately 48 million addresses – more than twice the address space the whole country of China has (approximately 20 million addresses). In Asia, IPv4 addresses are so rare that providers have no choice but to offer IPv6 commercial services. This is why the number of ISPs offering IPv6 on a commercial level is much higher in Asia than in Europe and the U.S. However, it is only a matter of time before European and American ISPs will need to rethink their stance on IPv6. It is estimate that the official IPv4 address space will be exhausted by 2005 or 2006.

✓ NAT is an adequate short-term fix, but not a long-term solution. It doesn't allow for end-to-end security – for many current and future applications, especially in the area of portals and eCommerce, end-to-end security will be a requirement, and IPv6 can provide this.

✓ In the future, it will not only be personal or network computers that will require an IP address. There are more and more devices that need a permanent IP address. The day is approaching where a mobile phone, car, or TV will have an IP address. With these changes, the need for IP address space will increase exponentially. Future services will require a higher level of security and quality of service (QoS) that, while feasible, will not be economically viable with IPv4.

2. IPv6 features

The current version of IP – IPv4 – has not been substantially changed since 1981. IPv4 has proven to be robust, easily implemented and interoperable.

However, the initial design did not anticipate the following:

✓ The recent exponential growth of the Internet and the impending exhaustion of the IPv4 address space.

✓ The growth of the Internet and the ability of Internet backbone routers to maintain large routing tables.

✓ The need for simpler configuration.

✓ The requirement for security at the IP level.

✓ The need for better support for real-time delivery of data (also called quality of service – QoS).

To address these and other concerns, the ***I****nternet* ***E****ngineering* ***T****ask* ***F****orce* (IETF) has developed a suite of protocols and standards known as IPv6. This new version, previously called **IPng**, incorporates the concepts of many proposed methods for updating the IPv4 protocol.

The following are the features of the IPv6 protocol:

✓ *New Header Format* – The IPv6 header has a new format that is designed to keep header overhead to a minimum. IPv4 headers and IPv6 headers are not interoperable. A host or router must use an implementation of both IPv4 and IPv6 in order to recognize and process both header formats. The new IPv6 header is only twice as large as the IPv4 header, even though IPv6 addresses are four times as large as IPv4 addresses.

✓ *Large Address Space* – IPv6 has 128-bit (16-byte) source and destination IP addresses. With a much larger number of available addresses, address-conservation techniques (NAT) are no longer necessary.

✓ *Efficient and Hierarchical Addressing and Routing Infrastructure* – IPv6 global addresses used on the IPv6 portion of the Internet are designed to create an efficient and hierarchical routing infrastructure.

✓ *Stateless and Stateful Address Configuration* – IPv6 supports both stateful address configuration, such as address configuration in the presence of a DHCP server (*Dynamic Host Configuration Protocol*), and stateless address configuration (address configuration in the absence of a DHCP server).

✓ *Built-in Security* – Support for IPsec is an IPv6 protocol suite requirement. This requirement provides a standards-based solution for network security needs and promotes interoperability between different IPv6 implementations.

✓ *Better Support for QoS* – New fields in the IPv6 header define how traffic is handled and identified.

✓ *New Protocol for Neighboring Node Interaction* – is a series of Internet Control Message Protocol for IPv6 (ICMPv6) messages that manage the interaction of neighboring nodes (nodes on the same link).

✓ *Extensibility* – IPv6 can easily be extended for new features by adding extension headers after the IPv6 header.

3. The IPv4 to IPv6 transition

The transition between today's IPv4 Internet and a future IPv6-based one will be a long process during which both protocol versions will coexist.

The IPv6 specification introduces major modifications: the IP address length has been extended to 128 bits and the IP header format and the way header information is processed have been modified. Moving from IPv4 to IPv6 is not easy and the mechanisms to enable their coexistence and the transition between the two versions have to be standardized.

No general rule can be applied to the IPv4 to IPv6 transition process. For instance IPv6 could be pushed by a political decision to extend the number of IP addresses to sustain the economic growth of a country. Other transition plans will enable a gradual interoperability between IPv4 and IPv6 as transition evolves.

Some studies foresee that the transition period will last between present and 2030 – 2040; at that time, IPv4 networks should have totally disappeared.

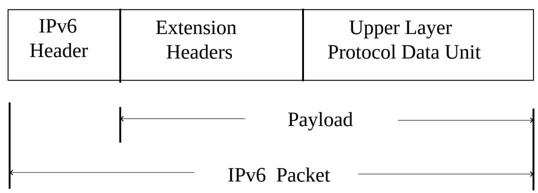
When IPv4 and IPv6 have to coexist, keeping IPv4 to IPv6 transition under control is essential to avoid the deployment of two parallel Internet infrastructures.

It is necessary to ensure the services continuity – IPv4 to IPv6 transition is not only an address or a routing issue. Available and emerging enhanced IPv4 services such as IP QoS, IP security, telephony over IP have to be continuously provided whatever the IP infrastructure might be.

4. Structure of an IPv6 packet. IPv6 header

The IPv6 header is a streamlined version of the IPv4 header. It eliminates fields that are unneeded or rarely used and adds fields that provide better support for real-time traffic.

Next figure shows the structure of an IPv6 packet:

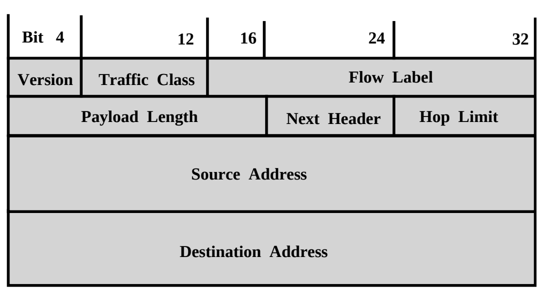


IPv6 Header – the IPv6 header is always present and is a fixed size of 40 bytes. The fields in the IPv6 header are described in detail later in this paper.

Extension Headers – zero or more extension headers can be present and are of varying lengths. A Next Header field in the IPv6 header indicates the next extension header. The IPv6 header and extension headers replace the existing IPv4 IP header with options. The new extension header format allows IPv6 to be augmented to support future needs and capabilities. Unlike options in the IPv4 header, IPv6 extension headers have no maximum size and can expand to accommodate all the extension data needed for IPv6 communication.

Upper Layer Protocol Data Unit – the upper layer protocol data unit (PDU) usually consists of an upper layer protocol header and its payload.

IPv6 Header – next figure shows the IPv6 header described in RFC 2460 – *Internet Protocol, Version 6 (IPv6). Specification*:



The fields in the IPv6 header are:

✓**Version** – 4 bits are used to indicate the version of IP (0110=6).

✓**Traffic Class** – indicates the class or priority of the IPv6 packet; size = 8 bits.

✓**Flow Label** – indicates that this packet belongs to a specific sequence of packets between a source and destination; the size of this field is 20 bits.

✓**Payload Length** – indicates the length of the IPv6 payload; size =16 bits.

✓**Next Header** – indicates either the first extension header (if present) or the protocol in the upper layer; the size of this field is 8 bits.

✓**Hop Limit** – indicates the maximum number of links over which the IPv6 packet can travel before being discarded; the size of this field is 8 bits.

✓**Source Address** – stores the IPv6 address of the originating host; the size of this field is 128 bits.

✓**Destination Address** – stores the IPv6 address of the current destination host; the size of this field is 128 bits.

5. Conclusion

Available globally addressable space on IPv4 Internet is decreasing. Growth is the major issue which has caused the need of a new IP generation. New technologies, such as a new generation of mobile phones, are going to necessitate a very significant number of IP addresses per user.

There are many different ideas and opinions about IPv6 – there are even people who think IPv6 will never come to life. Despite this perception, major companies around the world have been developing products and services using the next generation protocol.

The extended address space is certainly not the only reason to consider IPv6. The new protocol is optimized for the complex networks of the future. IPv6 has many advantages, such as integrated security, an improved addressing schema, and more efficient routing and autoconfiguration that should reduce administrative costs. The features supporting mobility with IPv6 also offer possibilities for wireless networks, which IPv4 could never handle.

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"Bogdan Vodă" University
Universităţii 23A, 430333 Baia Mare
România
E-mail address: ada@greenit.ro