<epam>

Internet Protocol

TRAINING
CENTER

<epam>

Aliaksandr Ramanovich

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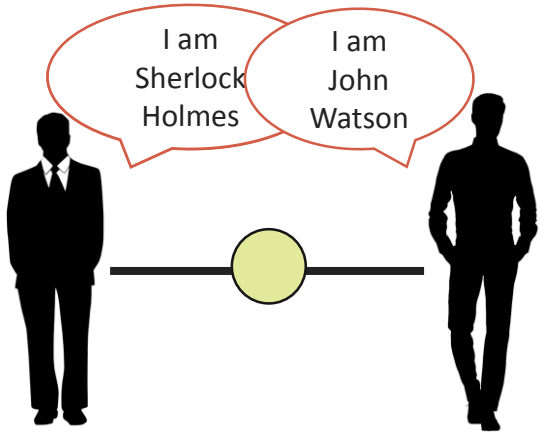
Agenda

- MAC
- IPv4
- IPv6

MAC ADDRESS

Communication and connection

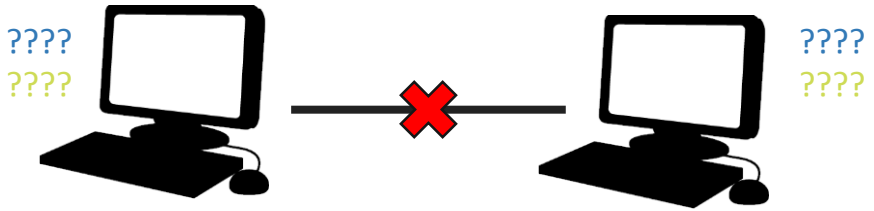


Sherlock

Holmes

John

Watson



OSI model

Application

Introduce — Data Link — ?

Handshake — Physical — Cable connection

MAC Address

MAC address is 48 bits long. 1 bit is one symbol 0 or 1. Usually address is represented as 6 bytes (8 bits) in hexadecimal format separated by a colon

A media access control (MAC) address is a unique identifier assigned to a network interface controller (NIC) for use as a network address in communications within a network segment. This use is common in most IEEE 802 networking technologies, including Ethernet, Wi-Fi, and Bluetooth.

Surname Name

00 : 26 : 57 : 00 : 1f : 02

OUI – organizationally unique identifier

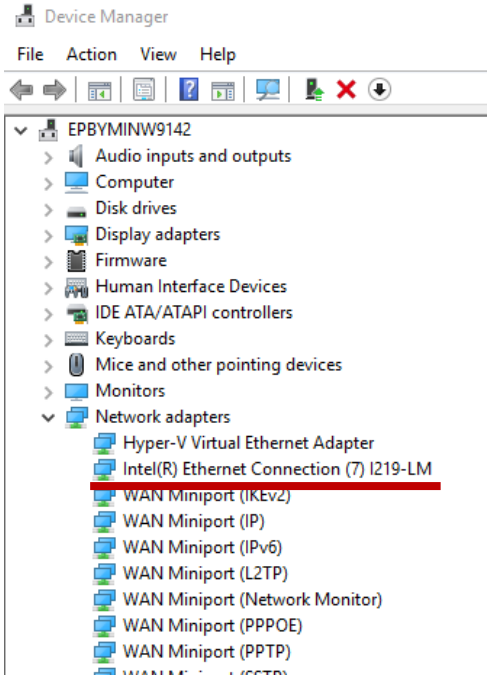
NIC Specific

OUIs are purchased from the Institute of Electrical and Electronics Engineers (IEEE) Registration Authority

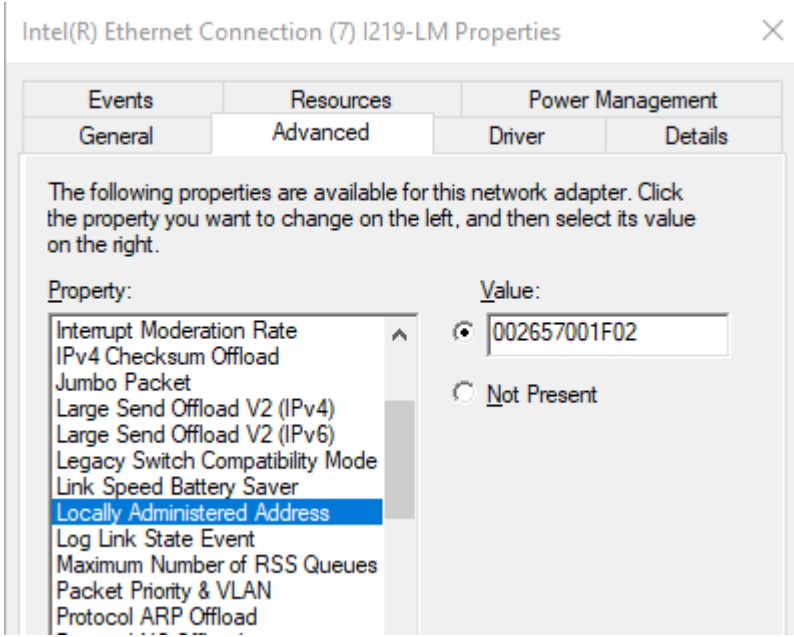
NIC Specific is issued by the manufacturer

Change MAC in Windows 10

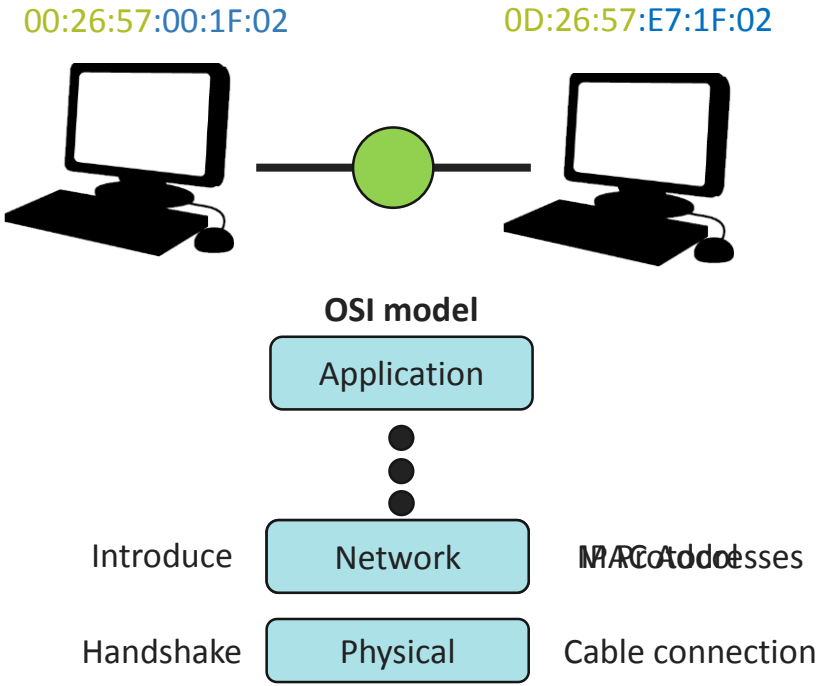
Open device manager and choose network device to config



Switch to the Advanced tab, find Locally Administered Address and type the value you need. Save the changes



Communication and connection

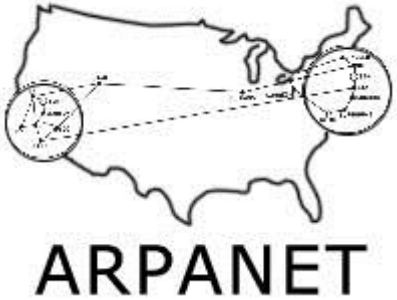


IPv4

Purpose

The Internet Protocol is designed for use in interconnected systems of packet-switched computer communication networks. The internet protocol provides transmitting blocks of data called datagrams from sources to destinations, where sources and destinations are hosts identified by fixed length addresses. The internet protocol also provides for fragmentation and reassembly of long datagrams, if necessary, for transmission through "small packet" networks.

Late 1960s



The Advanced Research Projects Agency Network (ARPANET) was a project which began in the Pentagon. In 1969, ARPANET developed packet switching. What would follow from these experiments was the development of the initial protocols which would define the internet, including TCP/IP and email developments

Road to IPv4

1970s

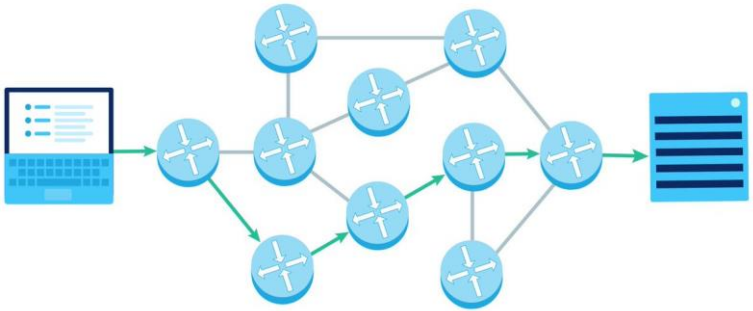
In 1973 Vint Cerf and Bob Kahn published the first version of TCP protocol. A few years later Jon Postel changed the TCP protocol to TCP/IP and split TCP and IP into two distinct operating layers. This became TCP v3 in 1978.

January 1980

The first formal standard version of IP was version 4 – TCP/IPv4 - defined in RFC 760.

Name	Route	Address
What we seek	How to get there	Where it is

Host_01



Host_01

192.168.156.3

IPv4 Address: RFC 760

Addresses are fixed length of four octets (32 bits)

An address begins with a one octet network number

Next three octets, called the “rest field” define local address

11000000 . 10101000 . 10011100 . 00000011

Decimal address notation looks more familiar

192 . 168 . 156 . 3

IPv4 Address: RFC 760

Result:

256 networks with a capacity over 16 million hosts

11000000 . 10101000 . 10011100 . 00000011

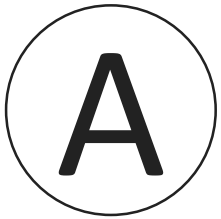
192 . 168 . 156 . 3

256 networks is not enough

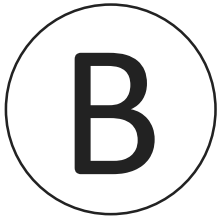
Classful Networks

September 1981

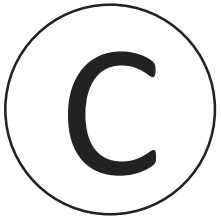
IPv4 was described in IETF (Internet Engineering Task Force) publication RFC 791. Network classes were defined there.



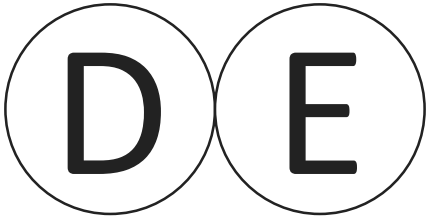
Networks: 128
Hosts: >16 million



Networks: 16,384
Hosts: 65,536

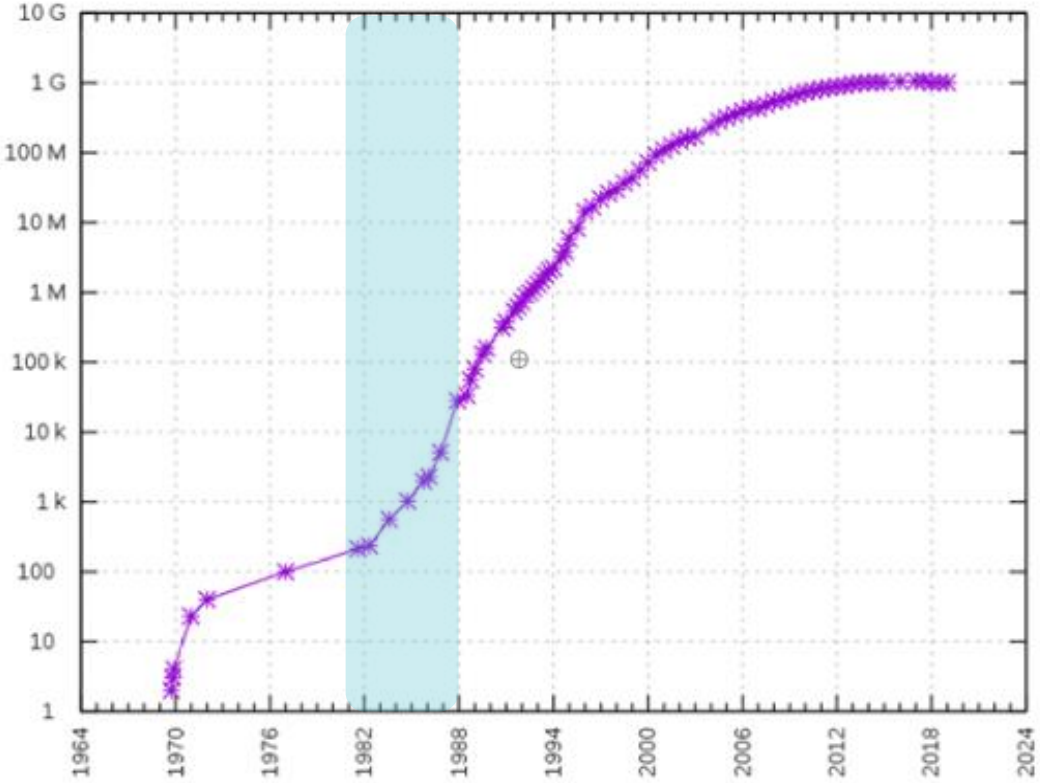


Networks: > 2 millions
Hosts: 256



Reserved

History

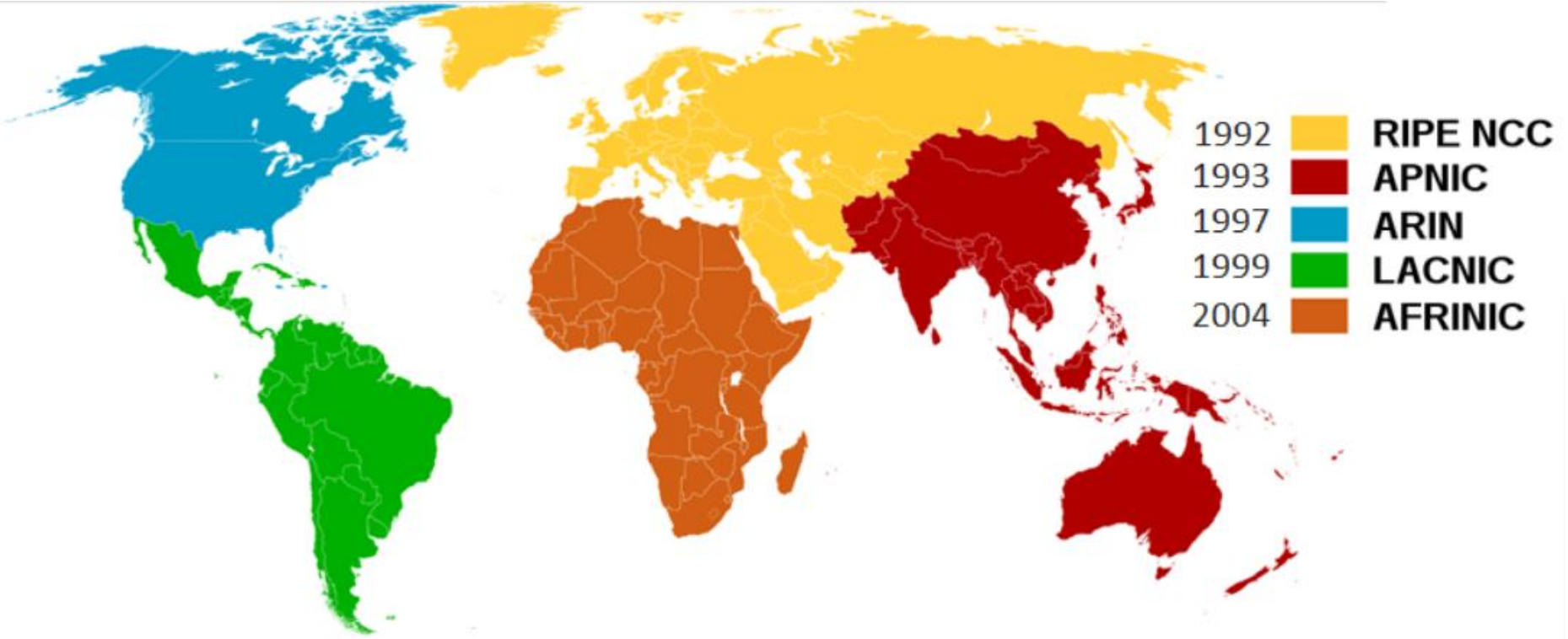

10 G
1 G
100 M
10 M
1 M
100 k
10 k
1 k
100
10
1
1964
1970
1976
1982
1988
1994
2000
2006
2012
2018
2024

Global IP Address Allocation

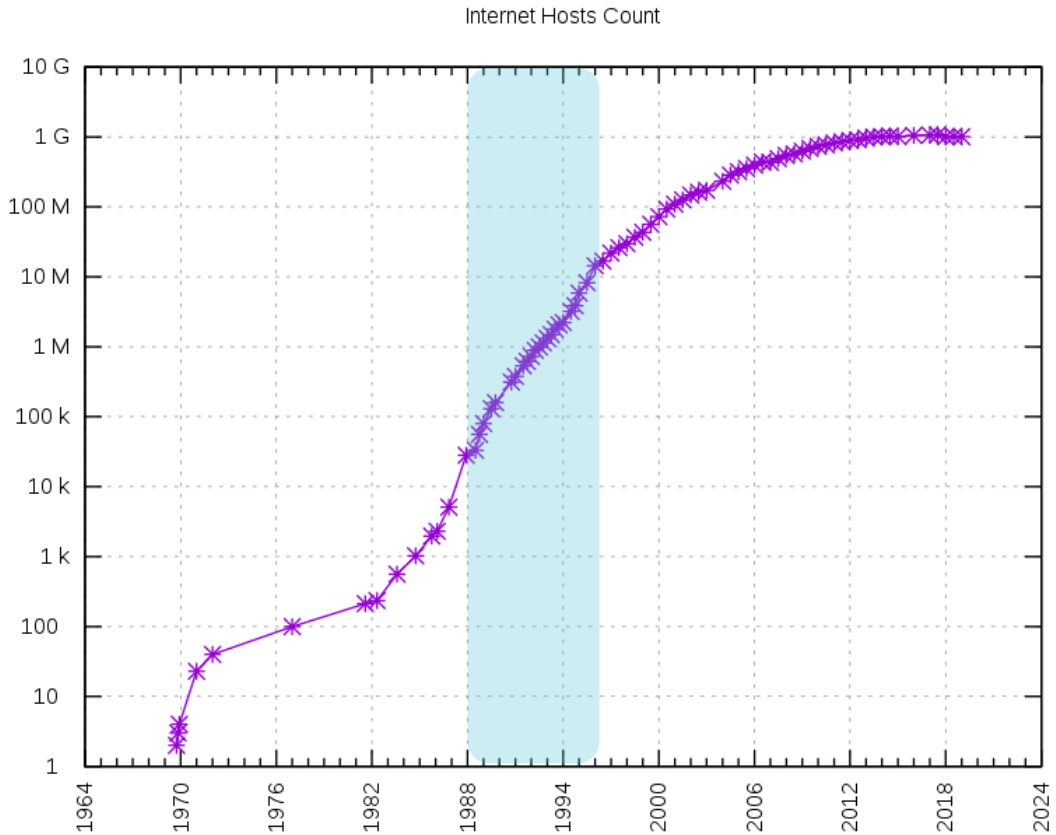
IANA was founded in 1988 to manage global IP address allocation, autonomous system number allocation, root zone management in the Domain Name System. For 10 years was administered principally by Jon Postel at the Information Sciences Institute which had a contract with the United States Department of Defense.

In 1998 ICANN was established and took control under IANA function.

Regional Internet Registry



History


Internet Hosts Count
10 G
1 G
100 M
10 M
1 M
100 k
10 k
1 k
100
10
1
1964
1970
1976
1982
1988
1994
2000
2006
2012
2018
2024

CIDR: RFC 1519

Classless Inter-Domain Routing (CIDR) - is a method for allocating IP addresses and IP routing based on variable-length subnet masking (VLSM) which was designed to replace classful networks, slow the growth of routing tables and rapid exhaustion of IPv4 addresses.

Private Networks

February 1996

The Internet has grown beyond anyone's expectations and globally unique address space seemed to be exhausted to fast. Since the Internet Assigned Numbers Authority (IANA) has reserved three blocks of the IP address space for private internets

10.0.0.0 - 10.255.255.255 (10/8 prefix)

172.16.0.0 - 172.31.255.255 (172.16/12 prefix)

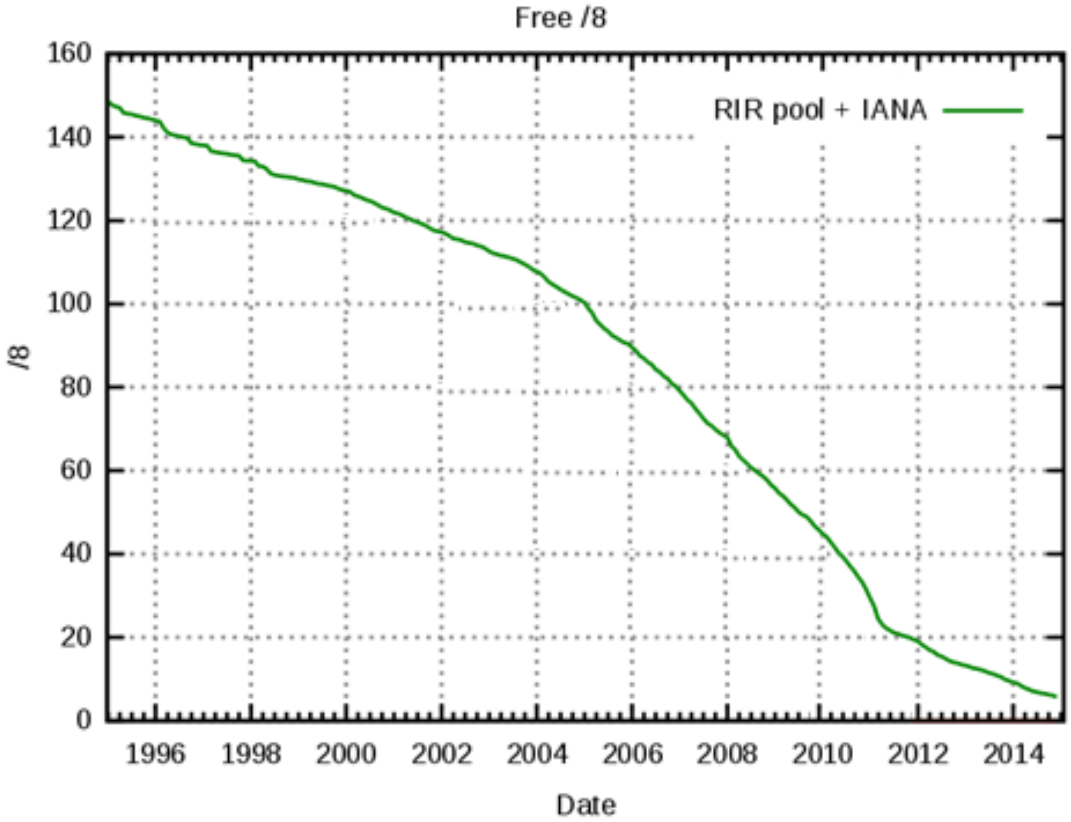
192.168.0.0 - 192.168.255.255 (192.168/16 prefix)

History

2011 - APNIC regional address pool exhausted

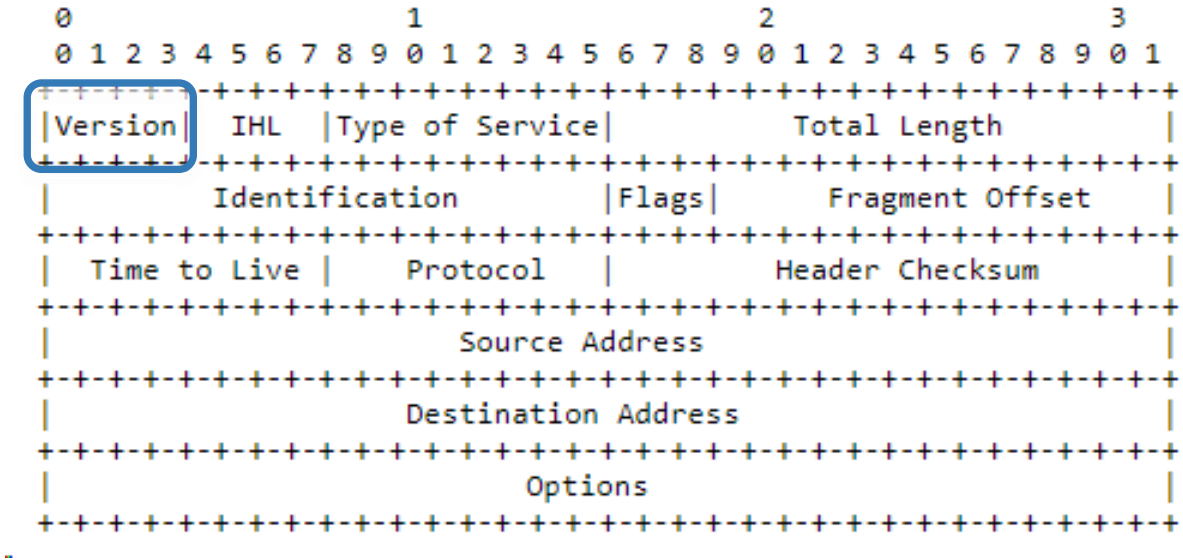
2014 - LACNIC regional address pool exhausted

2015 – RIPE and ARIN regional address pools exhausted



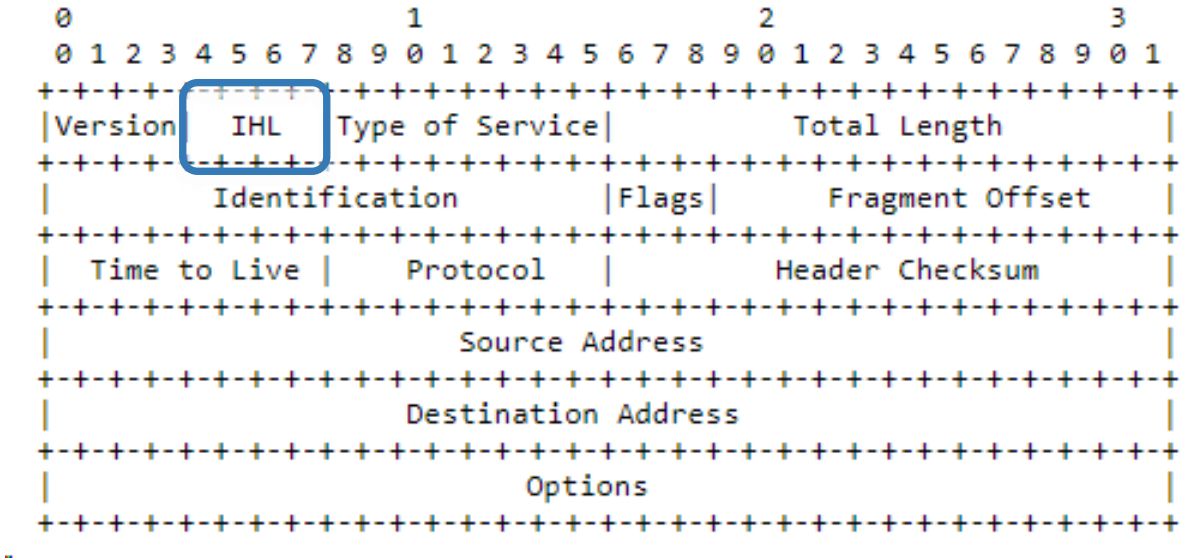
PACKET STRUCTURE

IP Header



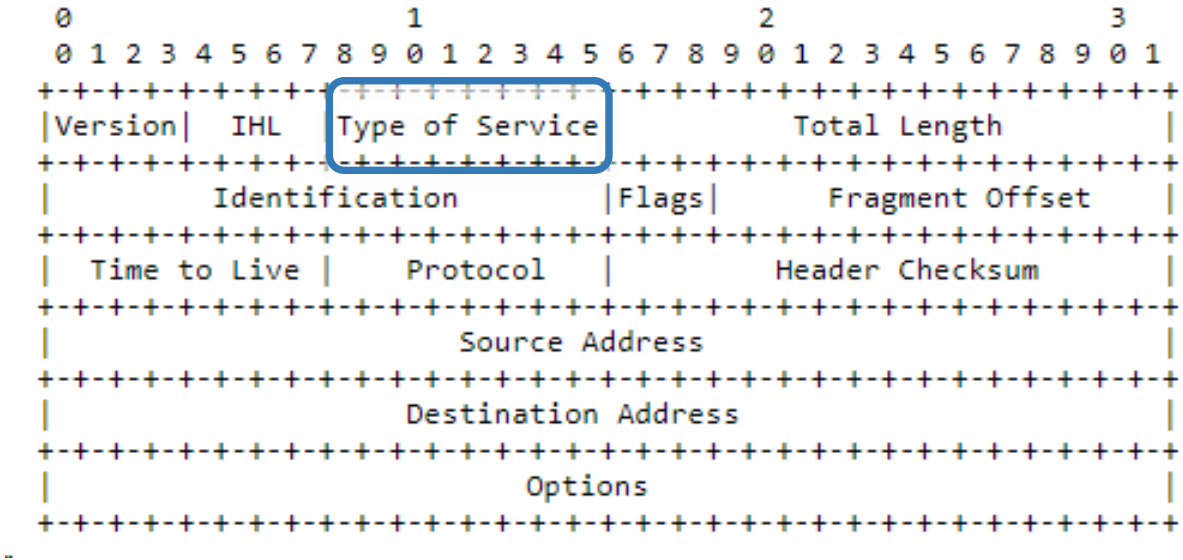
Version – always 4 for IPv4

IP Header



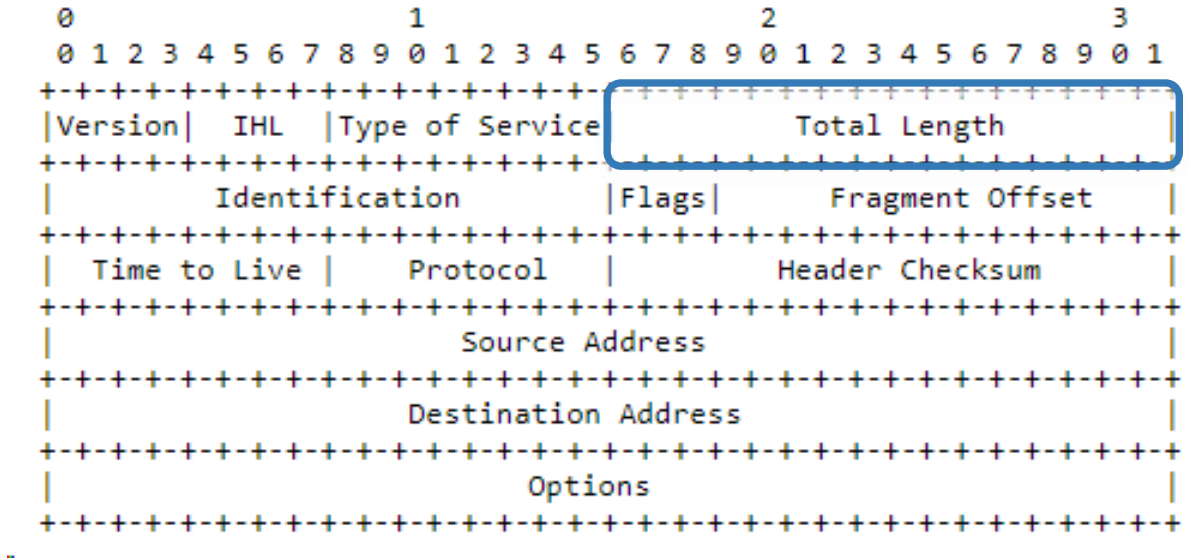
The IHL field contains the size of the IPv4 header, it has 4 bits that specify the number of 32-bit words in the header. The minimum value for this field is 5, which indicates a length of 5 × 32 bits = 160 bits = 20 bytes. The maximum value is 15, this means that the maximum size is 15 × 32 bits, or 480 bits = 60 bytes.

IP Header



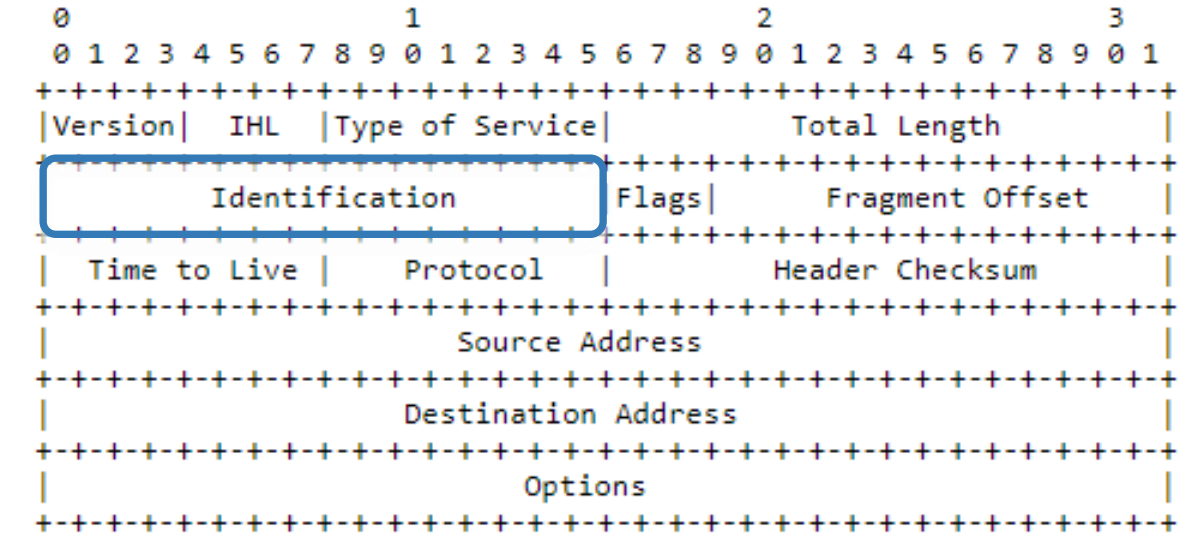
Type of service or Differentiated Services Code Point (DSCP) – this field specifies differentiated services (voice and streaming data)

IP Header



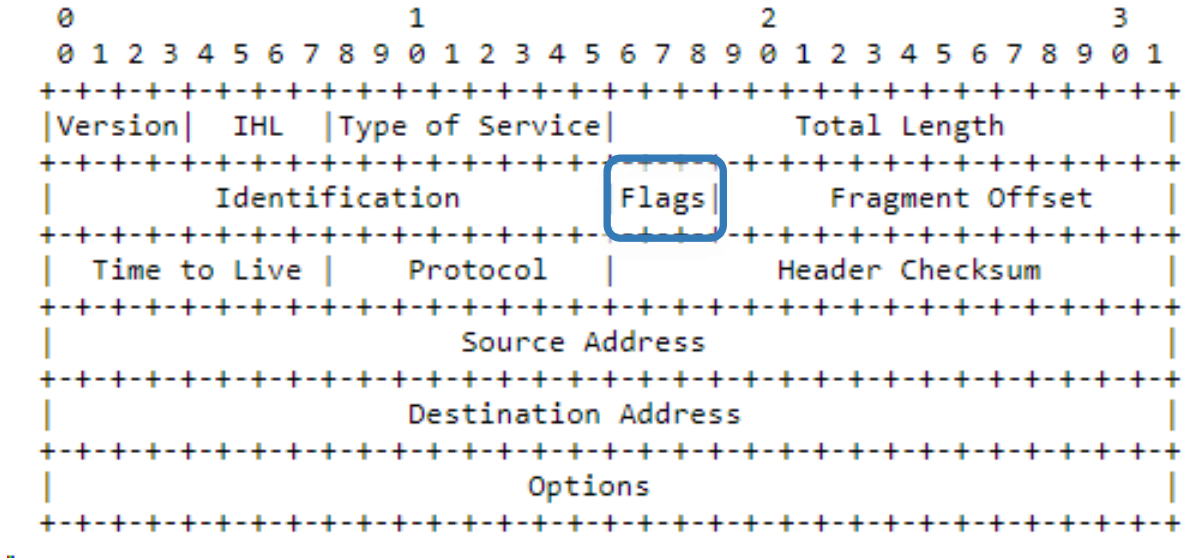
Total Length – from 20 up to 65,535 bytes

IP Header



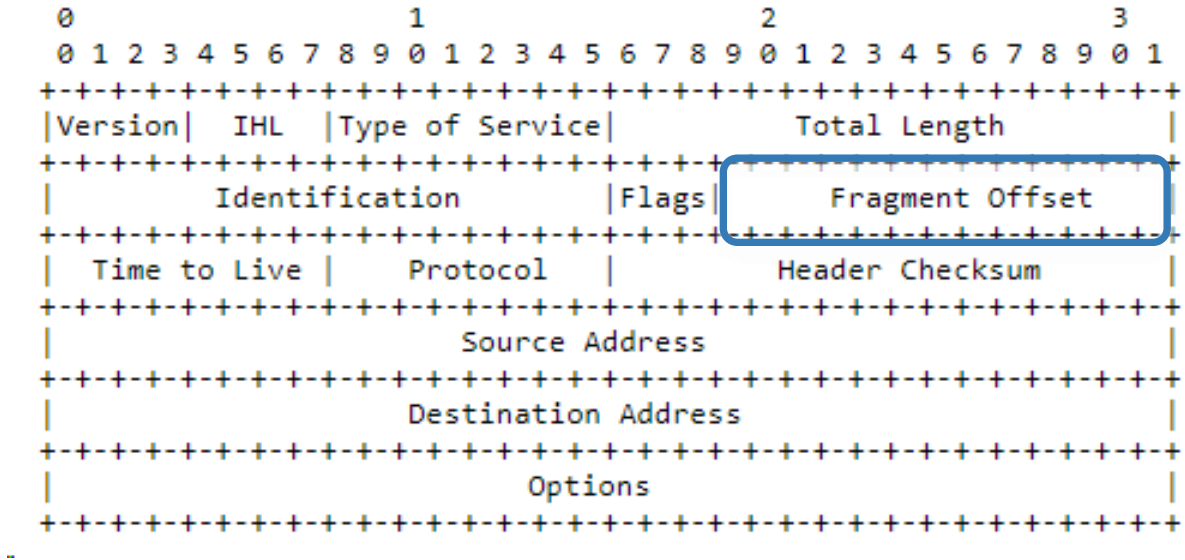
Identification - primarily used for uniquely identifying the group of fragments of a single IP datagram

IP Header



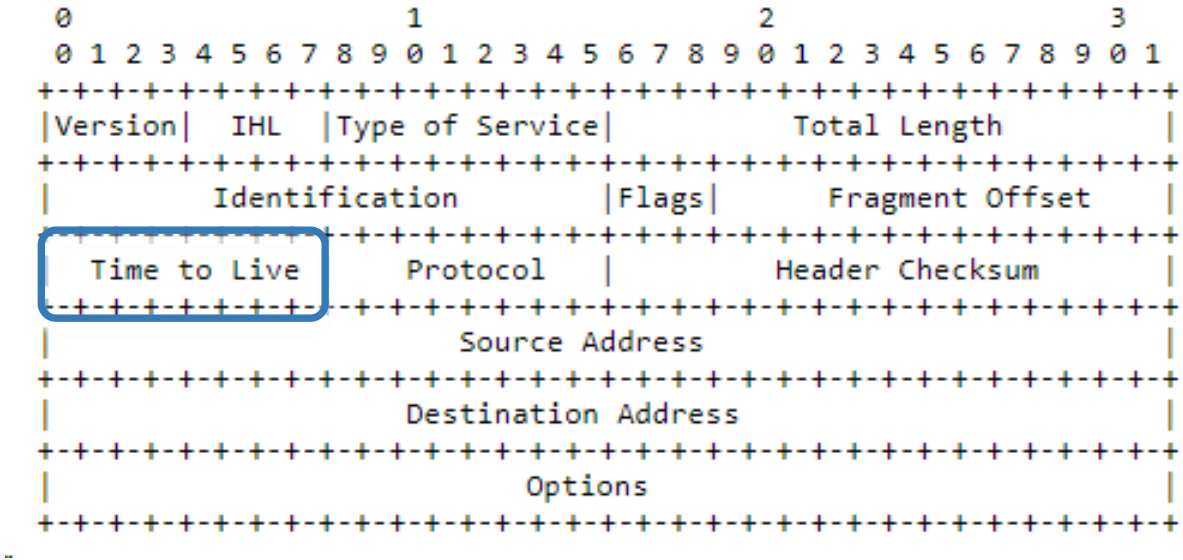
Flags - A three-bit field follows and is used to control or identify fragments

IP Header



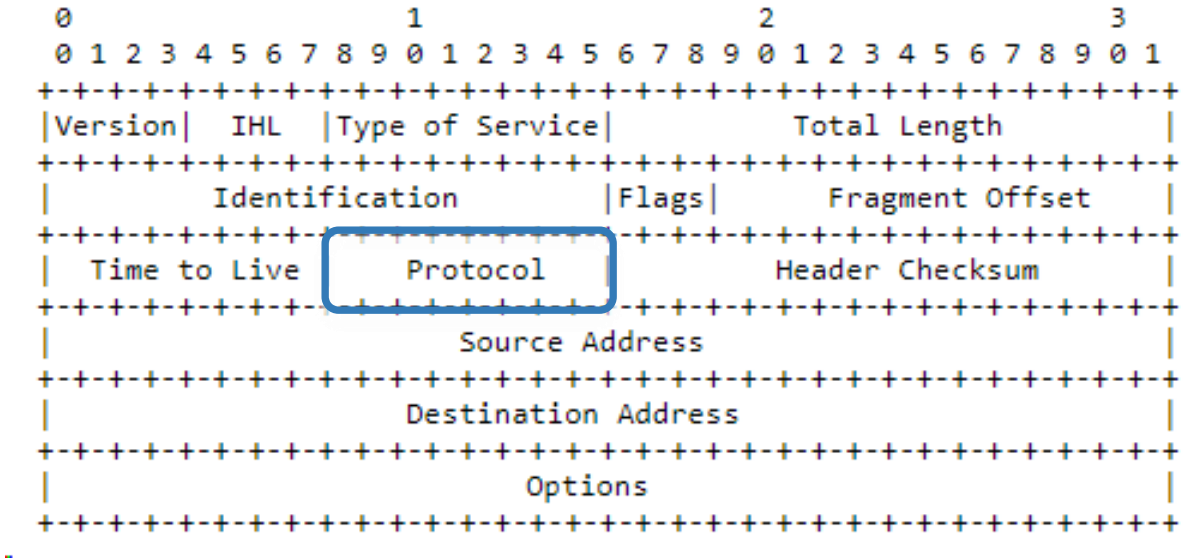
Fragment Offset - specifies the offset of a particular fragment relative to the beginning of the original unfragmented IP datagram

IP Header



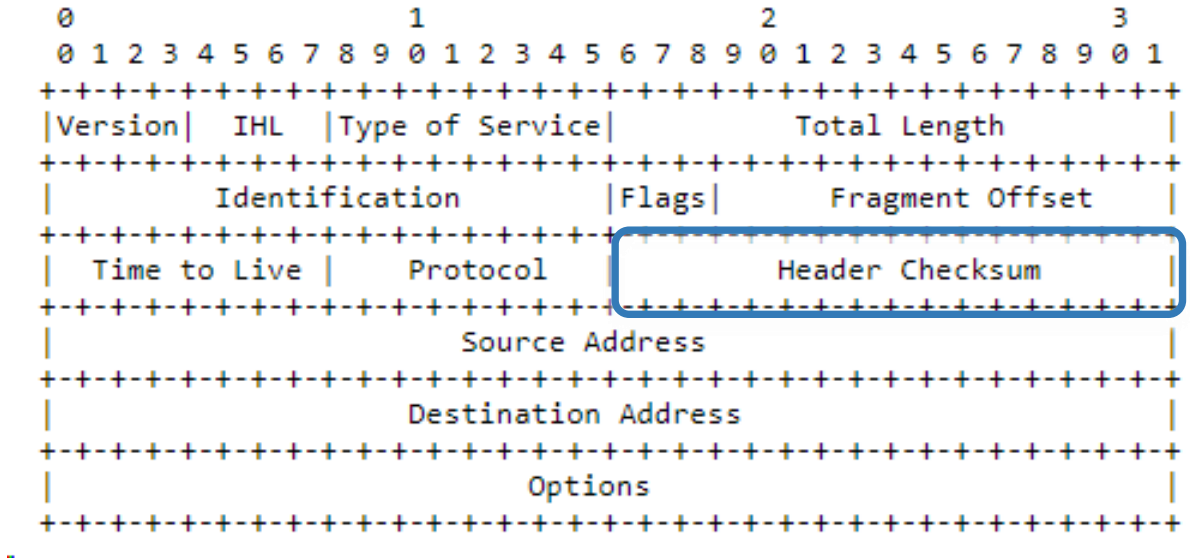
Time To Live (TTL) - limits a datagram's lifetime

IP Header



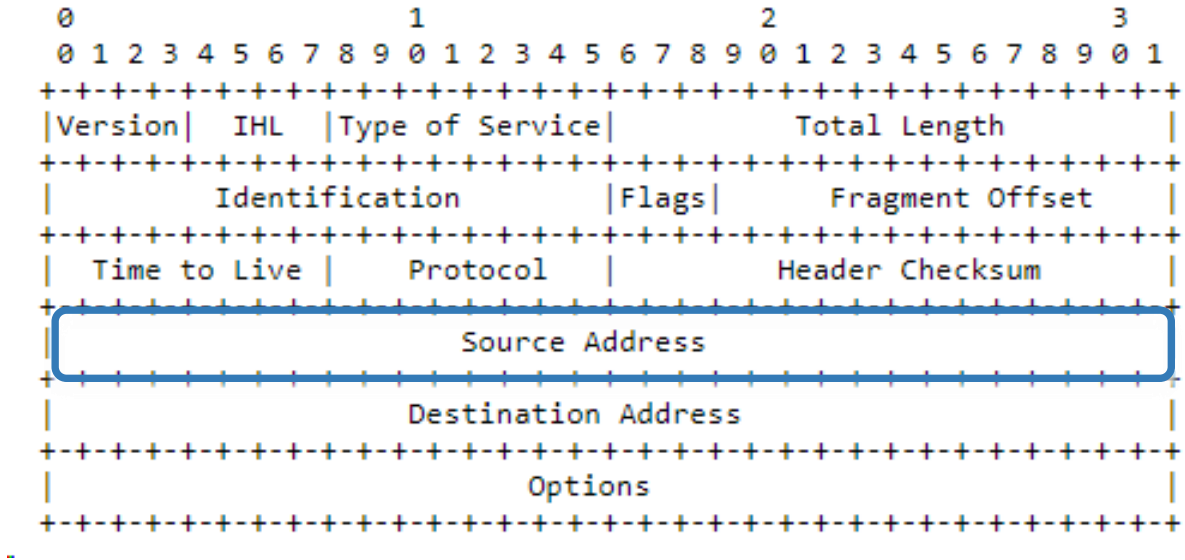
Protocol - defines the protocol used in the data portion

IP Header



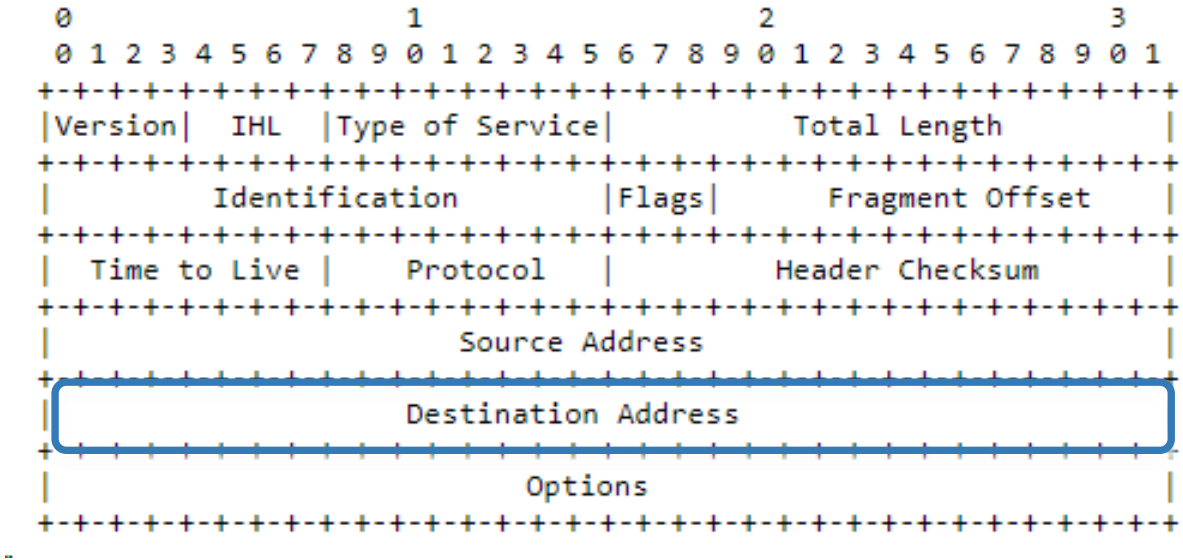
Header Checksum - used for error-checking of the header

IP Header



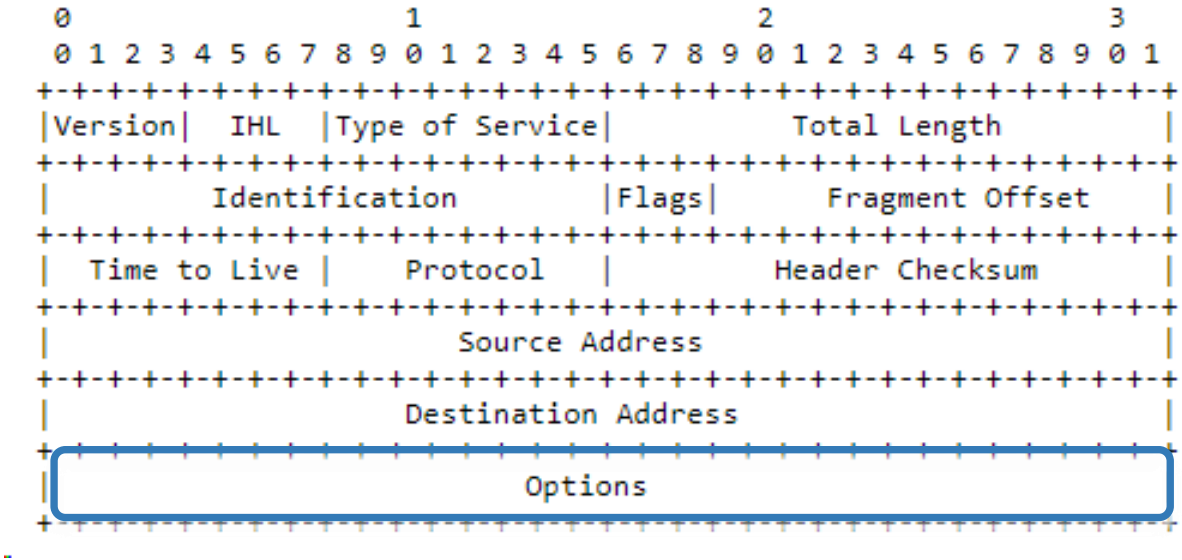
Source Address - this field is the IPv4 address of the sender of the packet

IP Header



Destination address - This field is the IPv4 address of the receiver of the packet

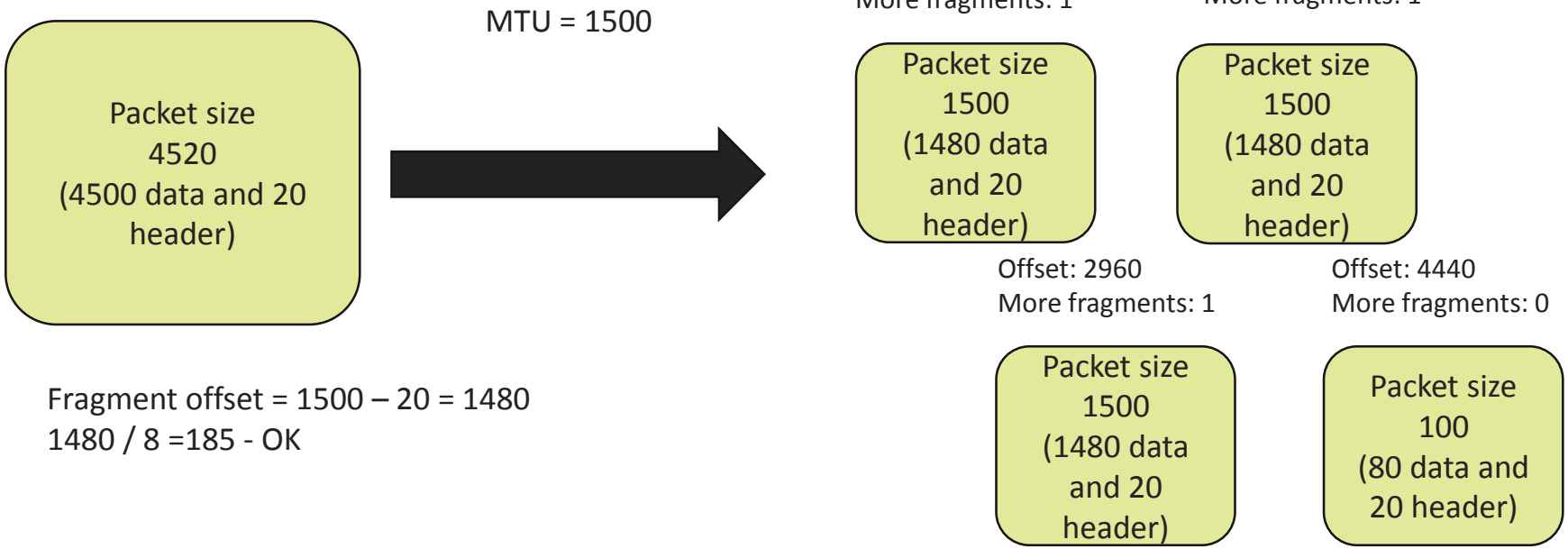
IP Header



Options - not often used. Packets containing some options may be considered as dangerous by some routers and be blocked

Fragmentation

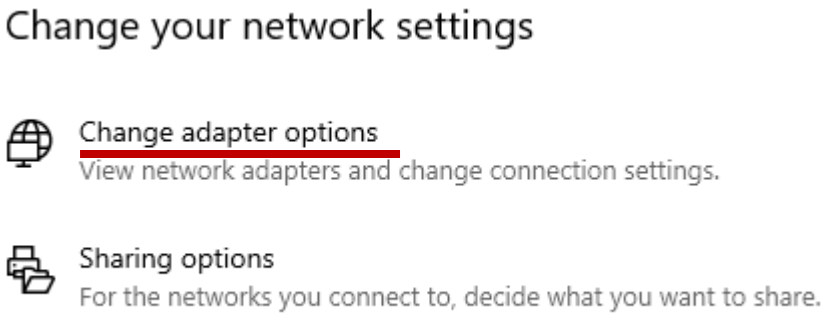
Maximum transmission unit (MTU) is the size of the largest protocol data unit (PDU) that can be communicated in a single network layer transaction. If packet size greater than MTU packet will be divided into fragments with the max size equal MTU.



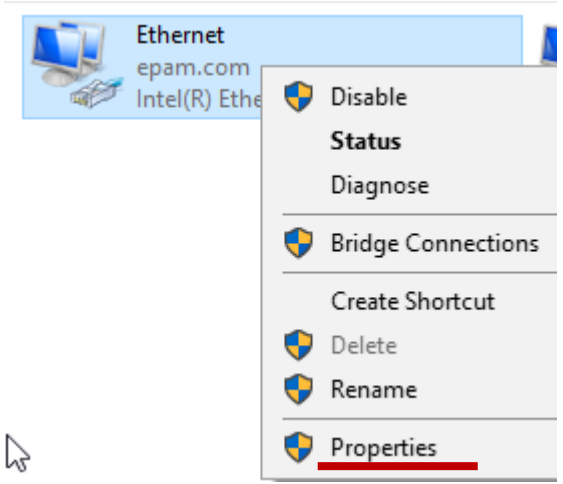
Fragment offset = 1500 – 20 = 1480
1480 / 8 =185 - OK

Configure IPv4 address in Windows 10

Open Network & Internet Settings – Change adapter options

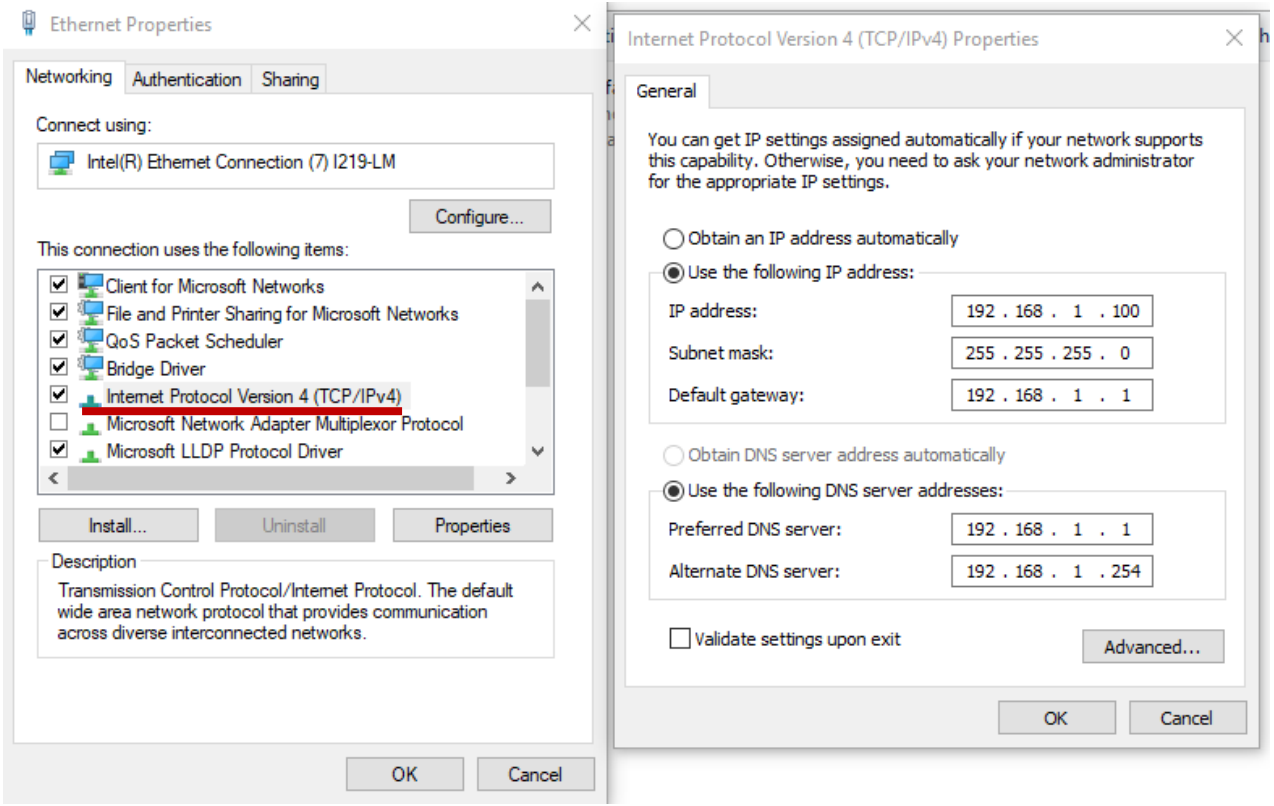


Choose a connection to configure and open its properties



Configure IPv4 address in Windows 10

Find Internet Protocol Version 4 (TCP/IPv4) and open it to configure.
Remember that your local IP address should be from one of Private Networks



IPv6

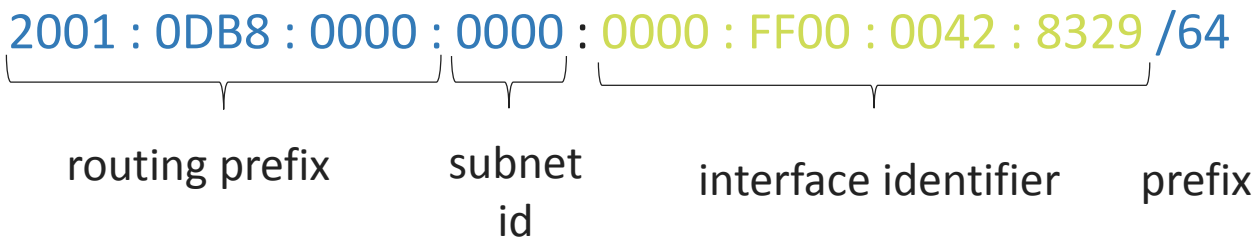
IPv6

December 1995	RFC 1884 – the first document about IPv6.
December 1998	IPv6 became a Draft Standard for the IETF with RFC 2373
July 2017	The IETF ratified IPv6 as an Internet Standard

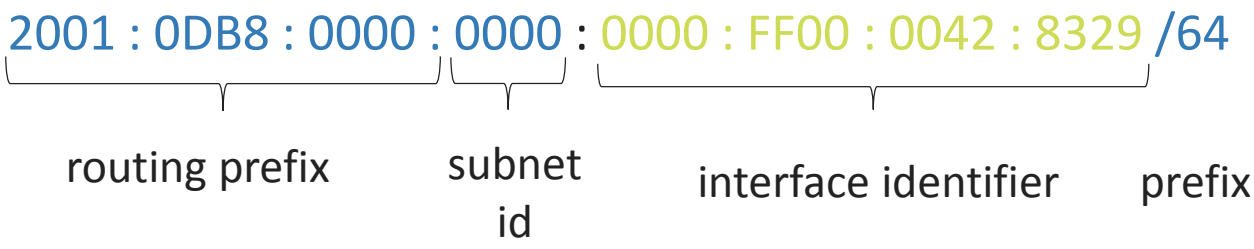
Address

IPv6 address is 128 bits long.

It’s useful to represent it as 8 groups of 4 hexadecimal numbers



Address



Address representation rules:

2001:0db8:0000:0000:0000:ff00:0042:8329

2001:db8:0:0:0:ff00:42:8329

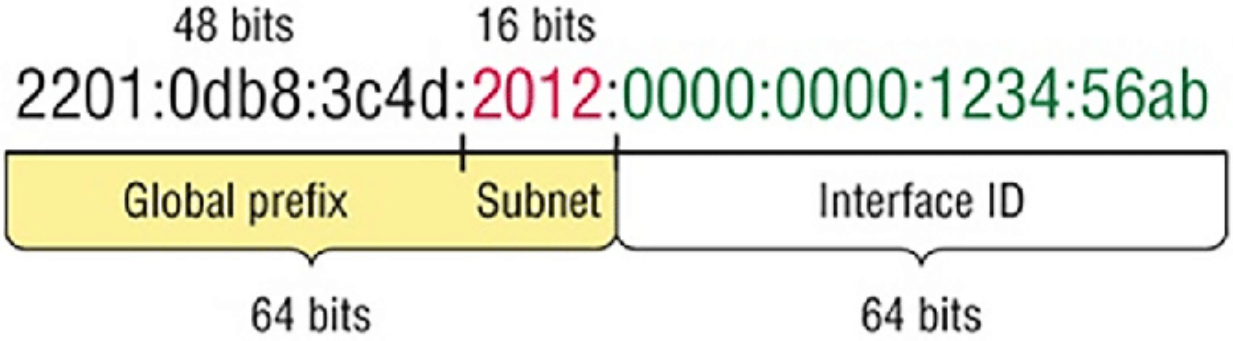
2001:db8::ff00:42:8329

1. One or more leading zeros from any groups of hexadecimal digits are removed

2. Consecutive sections of zeros are replaced with a double colon

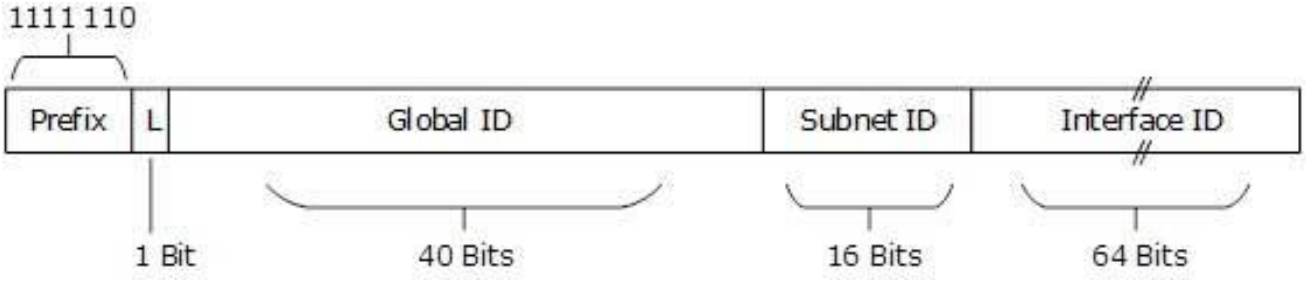
Global Unicast Address

This address type is equivalent to IPv4's public address. Global Unicast addresses in IPv6 are globally identifiable and uniquely addressable.



Unique-Local Address

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.
Therefore, Unique Local IPv6 address always starts with ‘FD’.



Link-Local Address

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.

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.

IPv6 Address Types

IPv6 is loooonger

IPv4

32 bits

4,3 billion addresses

IPv6

128 bits

340 billion addresses

billion

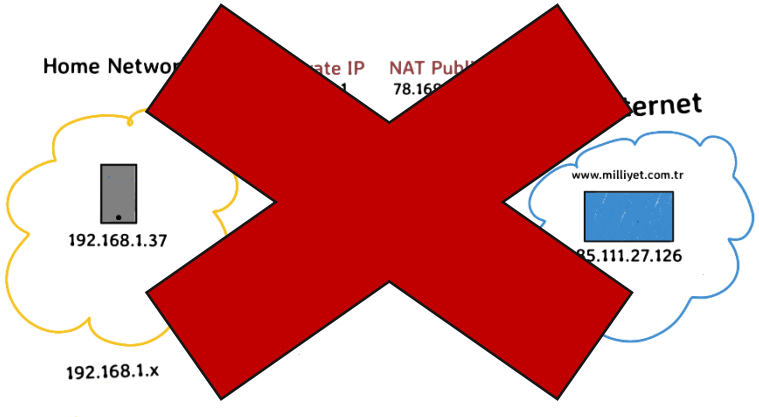
billion

billion

Large address space

- Fast and simple network configuration
- Better mobility features with Mobile IPv6
- More multicast and anycast capabilities
- No NAT

It provides better P2P connectivity
You don’t need NAT

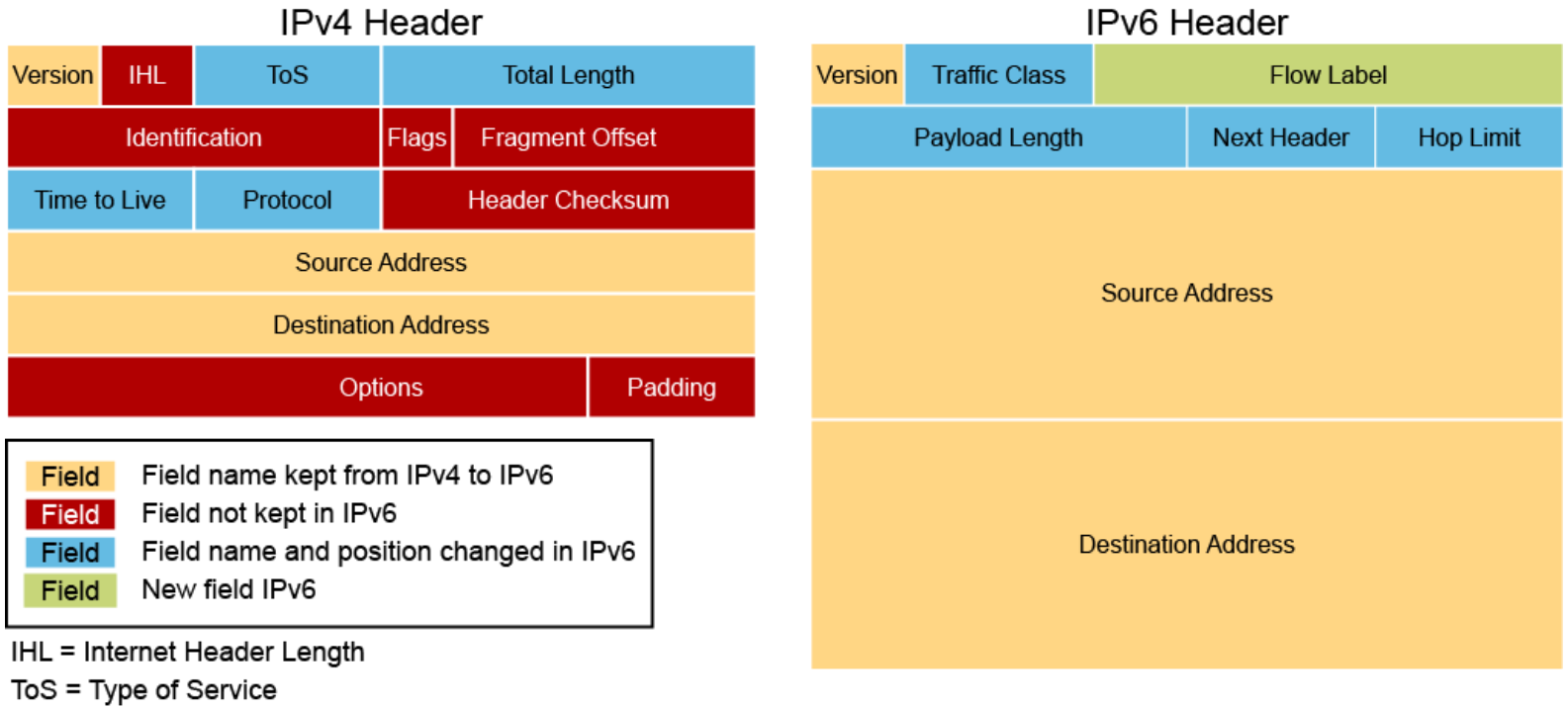


Autoconfiguration

IPv6 offers DHCPv6, which is an autoconfiguration similar to IPv4 DHCP and offers stateful address autoconfiguration.

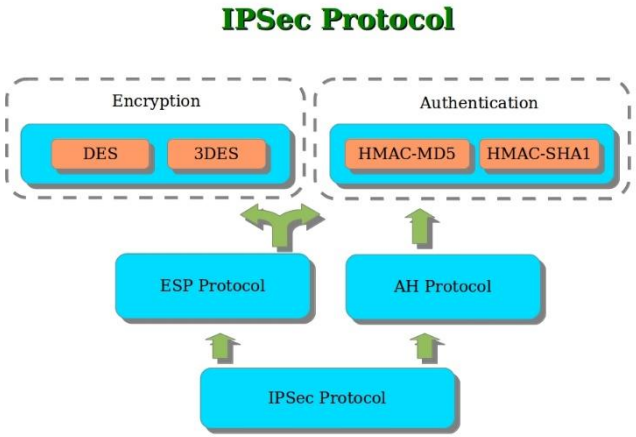
In addition, it also offers stateless or serverless address autoconfiguration when a host can automatically configure its own IPv6 address and does not need any assistance from a stateful address server

Simplified header structure



Security

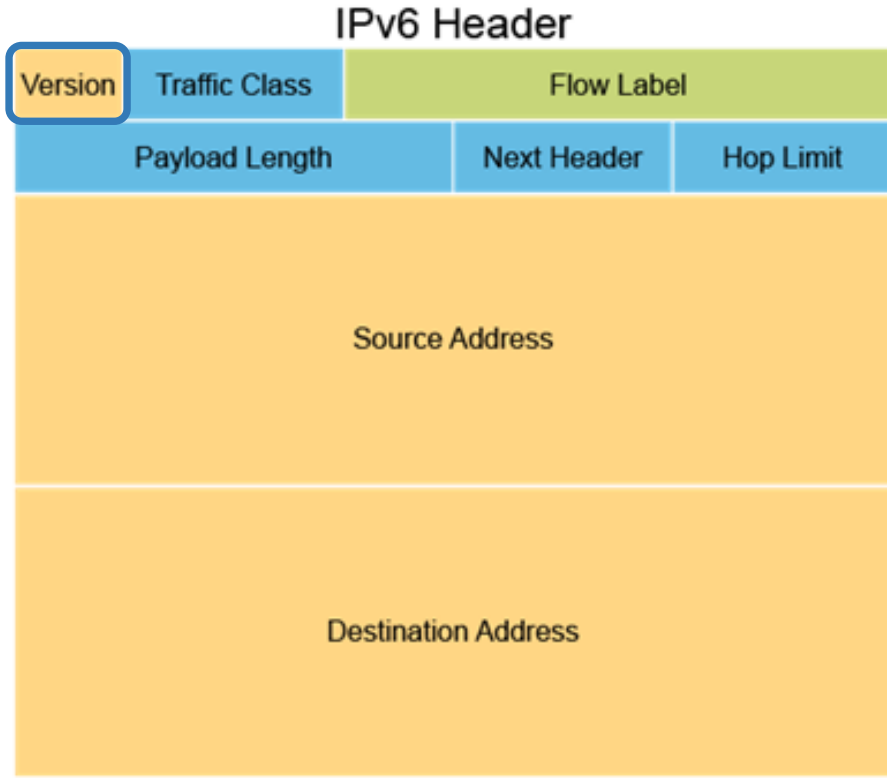
IPSec is a major protocol requirement and is one of the factors in ensuring that IPv6 provides better security than IPv4.



Better quality of service (QOS)

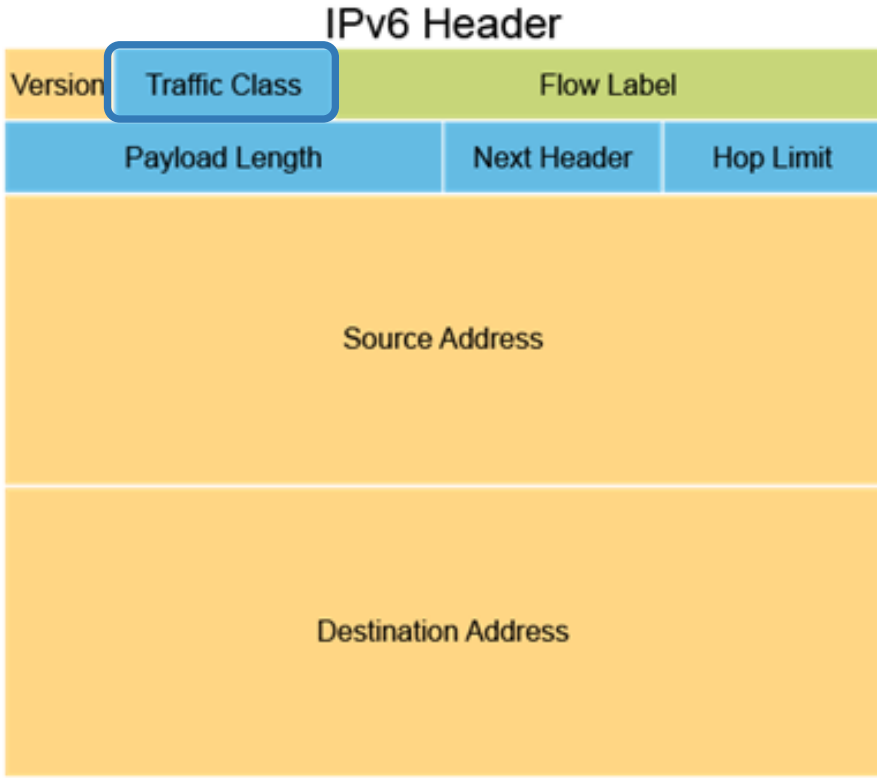
The Flow Label Field ensures that there is more efficient delivery of information from one end to another without the possibility of it being modified by intermediate systems. This ensures a high degree of QoS especially for peer-to-peer applications like VoIP and other real-time applications.

Header



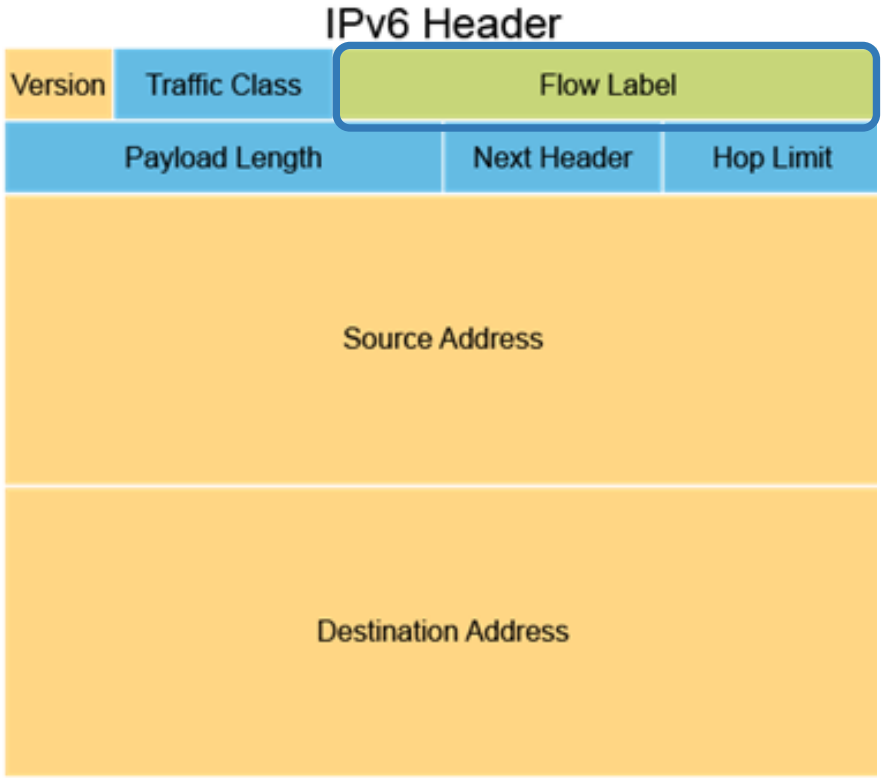
Version is the constant 6 (bit sequence 0110)

Header



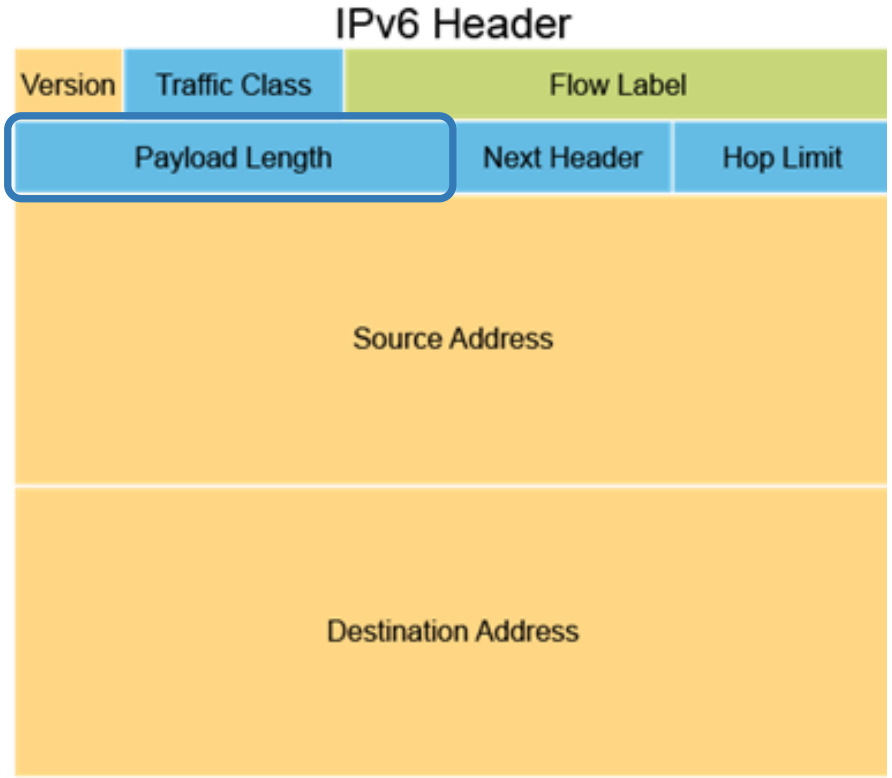
Traffic Class contains the 6-bit differentiated services code point (DSCP) value, which is also used for packet packets, as well as the 2-bit explicit congestion notification (ECN) value used to control traffic congestion.

Header



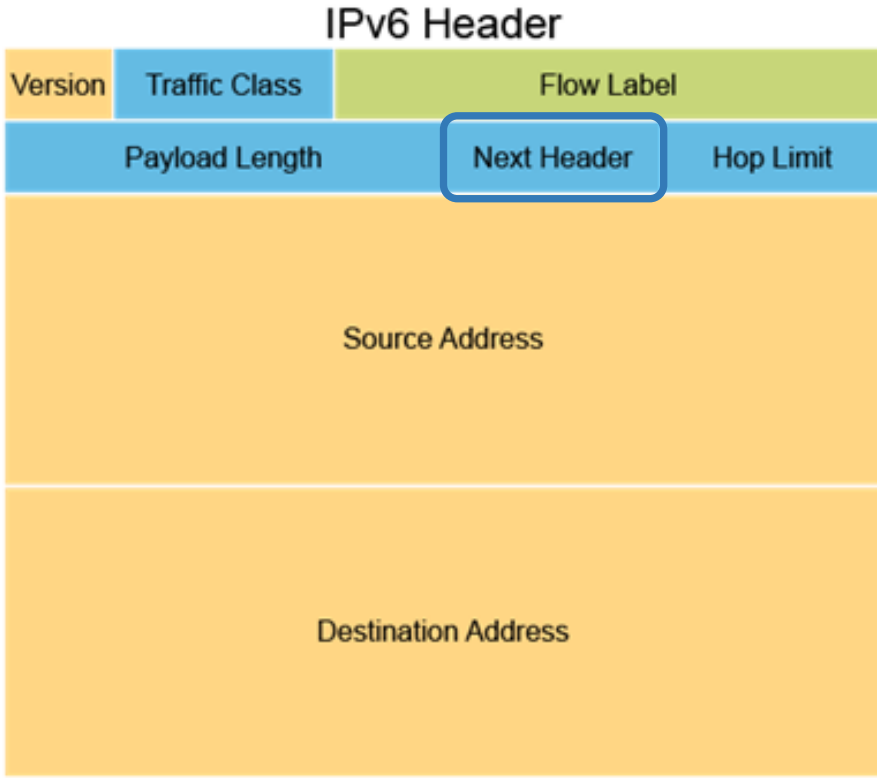
Flow label is a 20-bit field that provides a special service for real-time applications. Using this field, information about the need to maintain the same path for the packet flow is transmitted to routers and switches, which will help to avoid reordering them.

Header



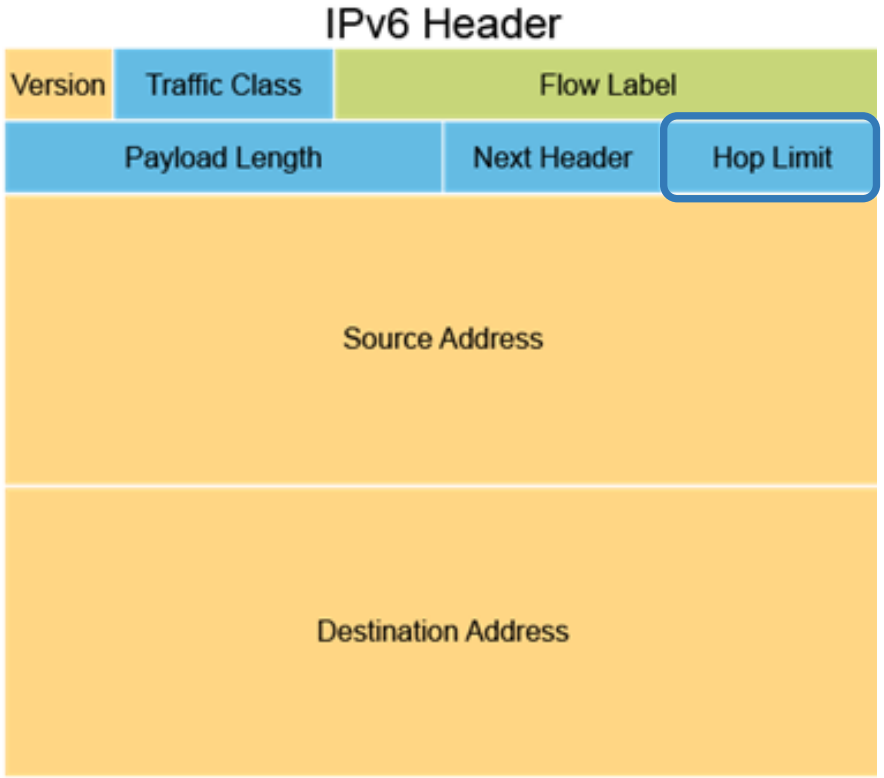
Payload Length is the size of the payload in octets, including any extension headers. The length is set to zero when a *Hop-by-Hop* extension header carries a Jumbo Payload option

Header



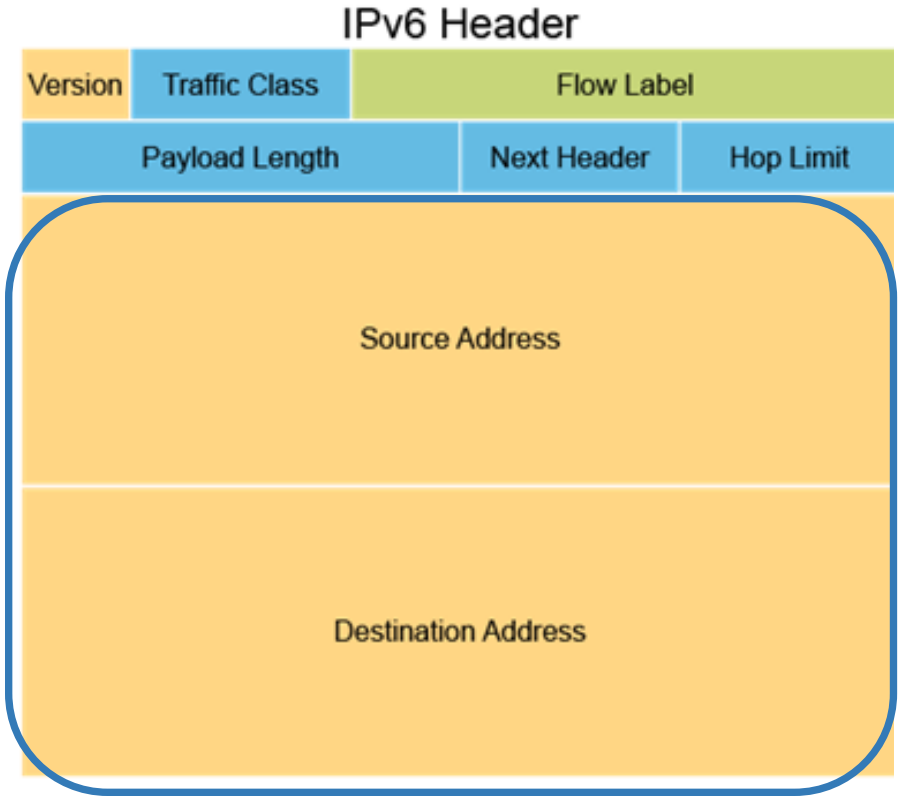
Next Header field usually specifies the transport layer protocol used by a packet's payload. When extension headers are present in the packet this field indicates which extension header follows.

Header



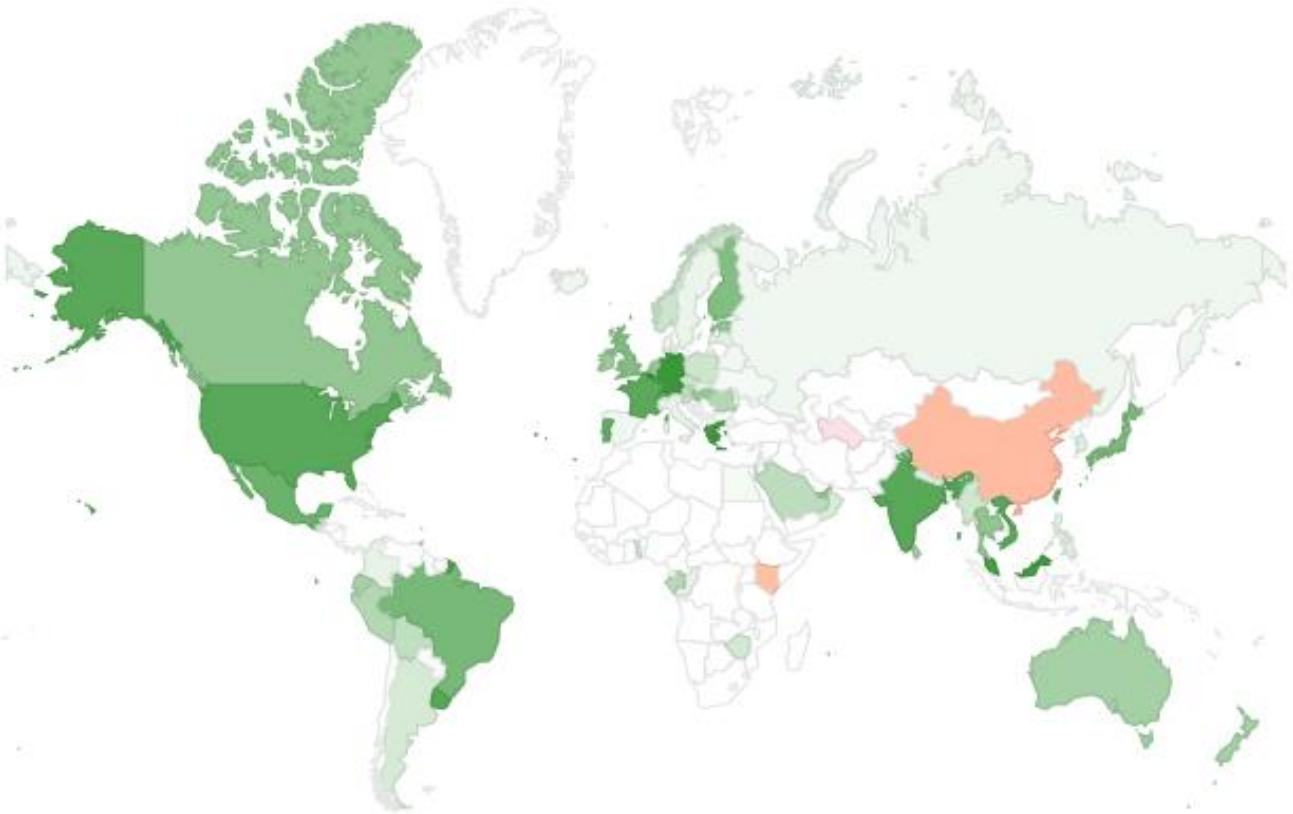
Hop Limit replaces the time to live field of IPv4. This value is decremented by one at each forwarding node and packet discarded if it becomes 0. However destination node should process the packet normally even if hop limit becomes 0.

Header

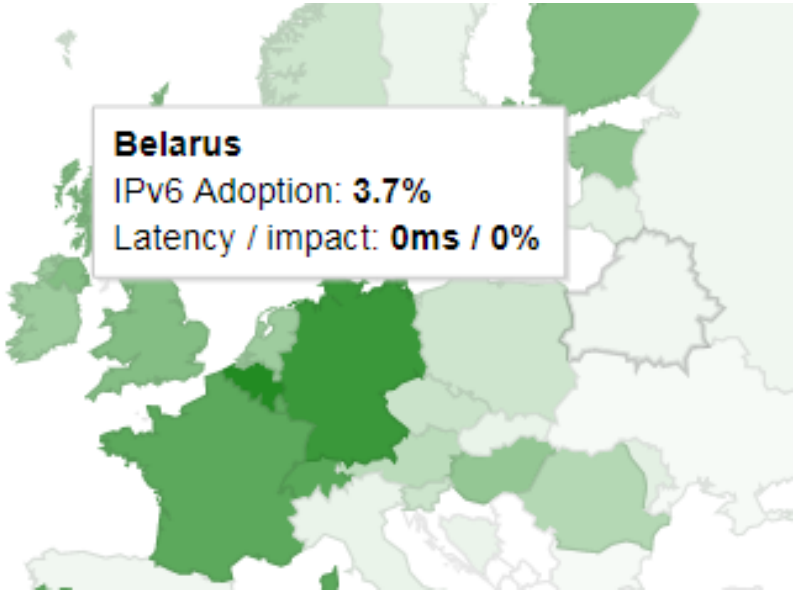


The IPv6 addresses of the sending and destination nodes

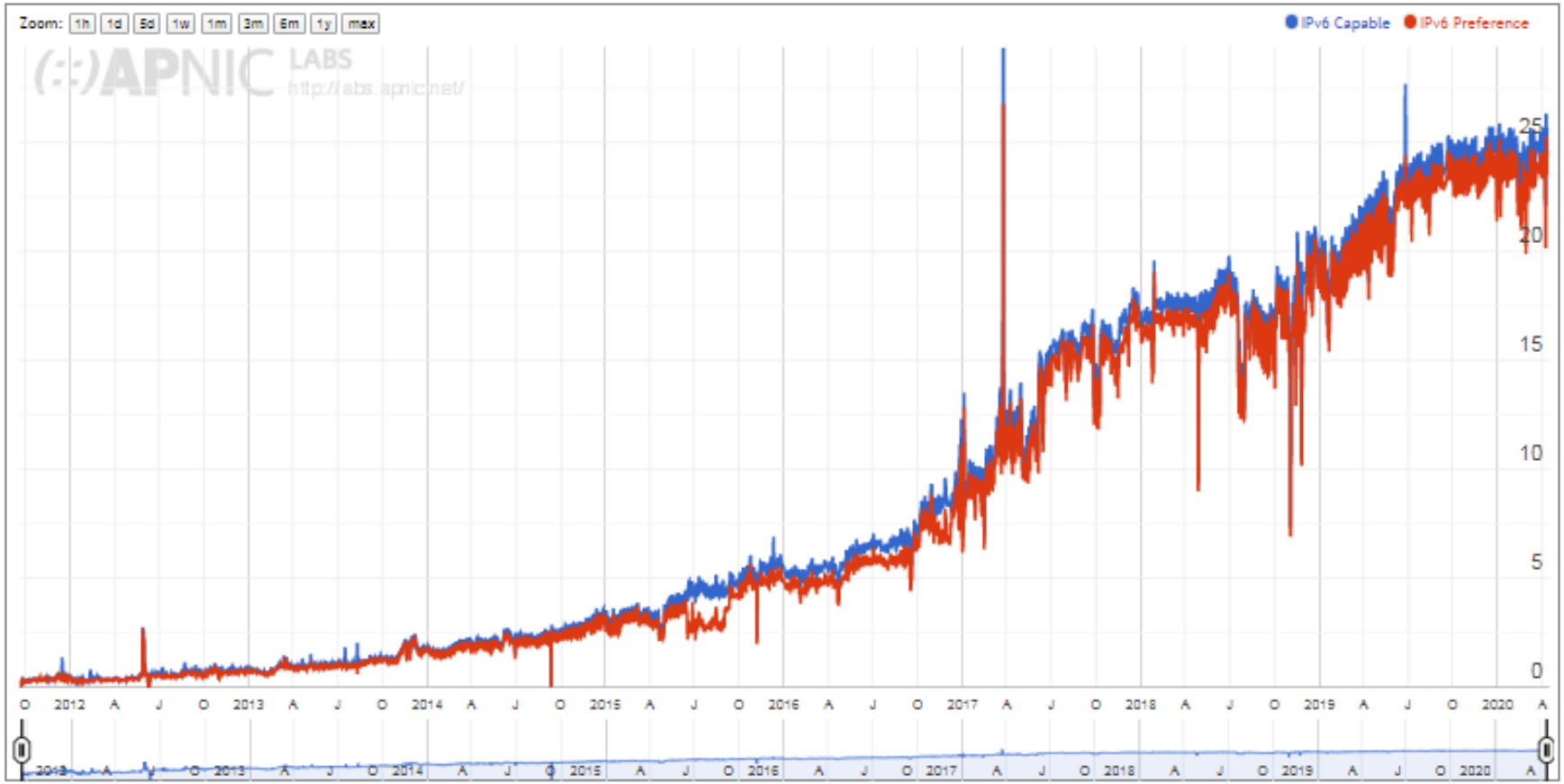
The availability of IPv6 connectivity around the world



The availability of IPv6 connectivity in Belarus

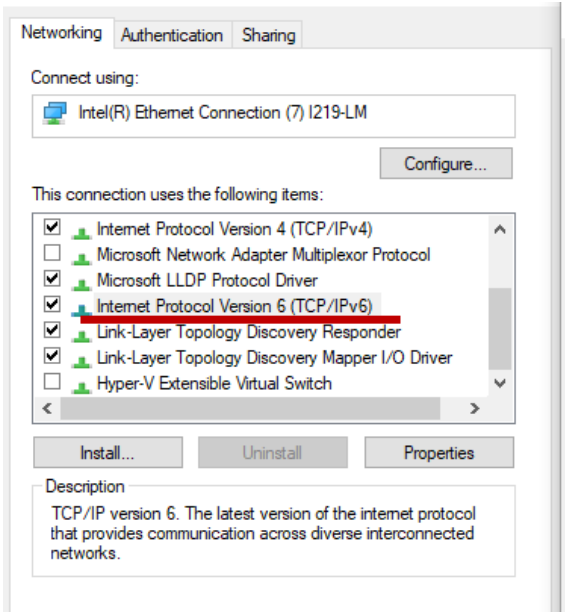


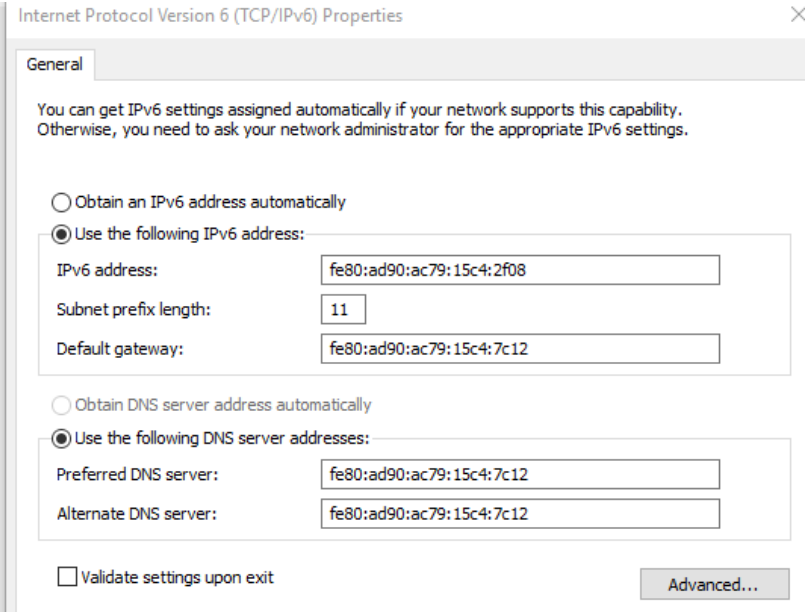
Statistics


Zoom: 1h 1d 5d 1w 1m 3m 6m 1y max
IPv6 Capable
IPv6 Preference
APNIC LABS
http://labs.apnic.net/
25
20
15
10
5
0
2012
2013
2014
2015
2016
2017
2018
2019
2020

Configure IPv6 address in Windows 10

Open adapter options in the same way as for configuring IPv4 properties.
Find Internet Protocol Version 6 (TCP/IPv6) and open it to configure.
Remember that your Link-Local IP address should start from fe80.





THANK YOU