1. What is the IP Protocol and IP addresses?

IP is the acronym for "Internet Protocol". This protocol was designed in the 1970s to connect computers from different networks. At the beginning, the protocol was for military use, later computers from universities, users and enterprises followed.
Internet as a worldwide information network is the result of the practical application of the IP protocol, that is, the result of the interconnection of all information networks in the world.

The IP address is a unique identifier that is applied to each device connected to an IP network. This way, different elements taking part in the network (servers, routers, user computers, etc) communicate among them using their IP address as identifier. In version 4 of the IP protocol (used nowadays), addresses consist of 4 numbers of 8 bits (an 8 bits number take a value from 0-255 range) that they use to be represented separated by points, for example: 155.54.210.63. A version 4 IP address has 32 bits, which is equivalent to 232 different IP addresses (4 billions more or less).

2. What is IPv6?

IPv6 is the acronym of "Internet Protocol Version 6". IPv6 is the Internet next generation protocol. IPv6 is the update of data network protocol on which Internet is based on. The IETF (Internet Engineering Task Force) developed the basic specifications in the1990s to substitute the actual version of Internet protocol, IP version 4 (IPv4).

What is an IPv6 address?

We already know that an IPv6 address has 128 bits. The lowest 64 bits identify a specific interface, and are designated as "interface identifier".
The highest 64 bits point out the "path" or the "prefix" of the network or router in one of the links in which such interface is connected.
The IPv6 address, is consequently formed, combining the prefix with the interface identifier.

What are the special IPv6 addresses?

- Auto-return or loopback virtual address. This address is specified in IPv4 with 127.0.0.1 address. In IPv6, this address is represented as ::1.
- Not specified address (::). It will never be allocated to any node since it is used to point absence of address.
- IPv6 over IPv4 dynamic/automatic tunnels. They are designated as IPv4 compatible IPv6 addresses, and allow to send IPv6 traffic over IPv4 networks in a transparent way. They are represented as ::, for example ::156.55.23.5.
- IPv4 over IPv6 addresses automatic representation: they allow that IPv4 only nodes could still work in IPv6 networks. They are designated as "mapped from IPv4 IPv6 addresses. They are represented as ::FFFF:, for example ::FFFF.156.55.43.3

Is it possible to have an IPv4 and an IPv6 addresses simultaneously?

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Yes. Most of the operative systems that currently support IPv6 allow the simultaneous use of both protocols. This way, the communication with IPv4 only networks as well as IPv6 only networks is possible, and the use of the applications designed for both protocols.

3. Why the need for a new IP Protocol like IPv6?

IPv4 has demonstrated, by means of its long life, a flexible and powerful design, but it is starting to present problems, with the increase of the IP address demand being the major one.
New users in populated countries like China or India and new technologies with always connected devices (xDSL, cable, PLC, PDAs, UMTS mobile telephones, etc) are causing the quick consumption, in a practical way, of available IPv4 addresses.
IPv6 resolves this problem by means of creating a new IP address format, so the number of IP addresses allows for more device sto connect to Internet.

4. What are the main advantages of IPv6?

Scalability: IPv6 has 128 bits addresses versus 32 bits IPv4 addresses. IPv6 offers a 2128 space (340.282.366.920.938.463.463.374.607.431.768.211.456). This is equivalent to 665.570.793.348.866.943.898.599 per square meter of the land surface.
Security: IPv6 includes security in its specifications like information encryption and the authentication of the source of this information.
Real time applications: To provide real time traffic better support (e.g. videoconference), IPv6 includes flows labeled in its specifications. By means of this mechanism, routers can recognise the end-to-end flow to which transmitted packets belong to.
Plug and Play: IPv6 includes, in its standard, the "plug and play" mechanism, to facilitate to users the connection of their equipments to the network. The configuration is automatically made.
Mobility: IPv6 includes more efficient and stronger mobility mechanisms.
More clear and optimised specifications: IPv6 will follow IPv4 good practices and removes not used or obsolete IPv4 characteristics, getting an optimisation of Internet protocol. The idea is getting good things and removing bad ones of present protocol.
Addressing and routing: IPv6 improves the addressing and routing hierarchy.
Extensibility: IPv6 has been designed to be extensible and offers optimised support for new options and extensions.

5. NAT and limitations

What is the solution being used today?
Temporarily, to alleviate the lack of addresses, NAT (Network Address Translation) mechanisms are employed. This mechanism lies in using an only IPv4 address for an entire network to access to Internet. Unluckily, if we continue using IPv4, this mechanism will become permanent.

Why don’t we use NAT forever?

NAT implies that many applications can't be used, so these applications can only be used in intranets, since many protocols can't go through NAT devices:
- Multimedia applications like videoconference applications, telephony through Internet or video on demand don't work through NAT devices. This is due to RTC and RTCP protocols ("Real-time Transport Protocol" and "Real Time Control Protocol") use UDP with dynamic allocation of ports (NAT doesn't support this).
- Kerberos authentication needs the source address, that is modified by NAT devices en IP headers.
- IPSec allows data authentication, integrity and confidentiality. However, when NAT is used, IPsec loses integrity, since NAT changes the address in the IP header.
- Multicast, although it is possible, technically, its configuration with NAT is so complicated, that is not employed.
The idea is that NAT is eliminated with IPv6.

Find more on IPv6 Transition.