The Network Layer – IPv4 / IPv6

* The internet is a large number of LANs joined together. LANs can be connected to other LANs close by via ethernet, or for long distance LANs specialist technology can be used, such as routers.
* LANs generally consist of: PCs, servers, printers, switches, ethernet cables and there may also be one or more Wi-Fi access points. An example of a simple LAN would be a Small Office / Home Office or SOHO.
* Communications that occur within a LAN itself requires Layer 2 and Layer 1 communication, with ethernet being the default standard, and the addresses used are the MAC addresses.
* Communications outside of the LAN require the use of Layer 3 which involves the use of a router. The addresses used in these communications are the IP addresses.
* Generally, a computer has at least one NIC, and each mobile device has a Wi-Fi chip. Each of these devices gets their own unique IP address. However, we need a way to distinguish between all of the applications/programs on a computer. This is the role of the Transport Layer.
* RFC 791 defines the Internet Protocol, and it states that the addresses carried in the IP header are used to transmit internet datagrams towards their destination on a path that has been selected through routing. The fields in the IP header are used to fragment and reassemble the internet datagrams when necessary for transmission through “small packet” networks.

IPv4

* An IPv4 address is 32-bits long, and that’s the way the computer sees it. However, for us, we break it down into 4 bytes, and then convert each byte into the base 10 format and write down the address as four integers (ranging from 0-255) separated by dots. For example, 143.117.69.72
* Each NIC / Wi-Fi card on the public internet needs its own unique IP address (RFC 1918)
* Graphical user interface, text, application, email

  Description automatically generatedThe Structure of the IPv4 header looks like this:
* The protocol field within the header is 8-bits long, so there are 256 max values. These values are defined in an RFC. Some of these values (in hexadecimal) are:

Graphical user interface, application

Description automatically generated

* If you want to buy an IP address, you usually do so from your Internet Service Provider (ISP). They are allocated blocks of IP addresses by the Regional Internet Authorities (RIR) They are also entrusted with this job by the Internet Assigned Numbers Authority (IANA).
* Initially, in order to assist routing, addresses were divided into classes. However, today due to Variable Length Subnet Mask (VLSM) and Classless Inter-Domain Routing (CIDR) routing is classless, but these were what the classes were:

Graphical user interface

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* IPv4 Unicast = One computer talking to one other. (Enabled with TCP or UDP)
* IPv4 Multicast = One computer talking to several computers. (UDP)
* IPv4 Broadcast = One computer communicating with all computers on the network.
* There are, however, some IPv4 addresses that in accordance with RFC 1918, should never be routed onto the public internet. These address classes are:

Graphical user interface, text, application

Description automatically generated

* 127.0.0.1 is a special IPv4 address that’s used as the loopback in the computer. So, IP packets are sent from the Transmit (Tx) to the Receive (Rx) within the same computer which allows the testing of the software layers but not the physical layers.
* You can build private networks, and then connect to the internet using NAT/PAT.
* Network Address Translation (NAT) / Port Address Translation (PAT) is a piece of software that a Router uses. The way it works is that it takes in the private addresses assigned to the computers connected to its network, and then whenever they want to connect to the public internet are assigned the SAME public internet IP address.
* The main reason NAT/PAT exists is because back when IPv4 was invented, scientists created IPv4 to use 32-bit long source and destination addresses, which provided over 4.2 billion different addresses, but they didn’t know how popular and common the internet would eventually become, and now we’ve ran out of IPv4 addresses, so this software was created in order to combat that as much as possible. However, something else was created to combat IPv4’s problems…IPv6.

IPv6

* IPv6 is an upgraded version of IPv4. It’s different from IPv4 because instead of having addresses that are 32-bits long, the source and destination IPv6 addresses are 128-bits long. This means that there is a massive total of 3.4 x 1038 different addresses.
* IPv6 also formats its addresses using hexadecimal. So, the 128 bits are divided into 8 groups of 16 bits, converted into hexadecimal and then separated by colons.
* Graphical user interface, application

  Description automatically generatedThe IPv6 IP header looks like this: