Ref: A. Leon Garcia and I. Widjaja, *Communication Networks*, 2nd Ed. McGraw Hill, 2006
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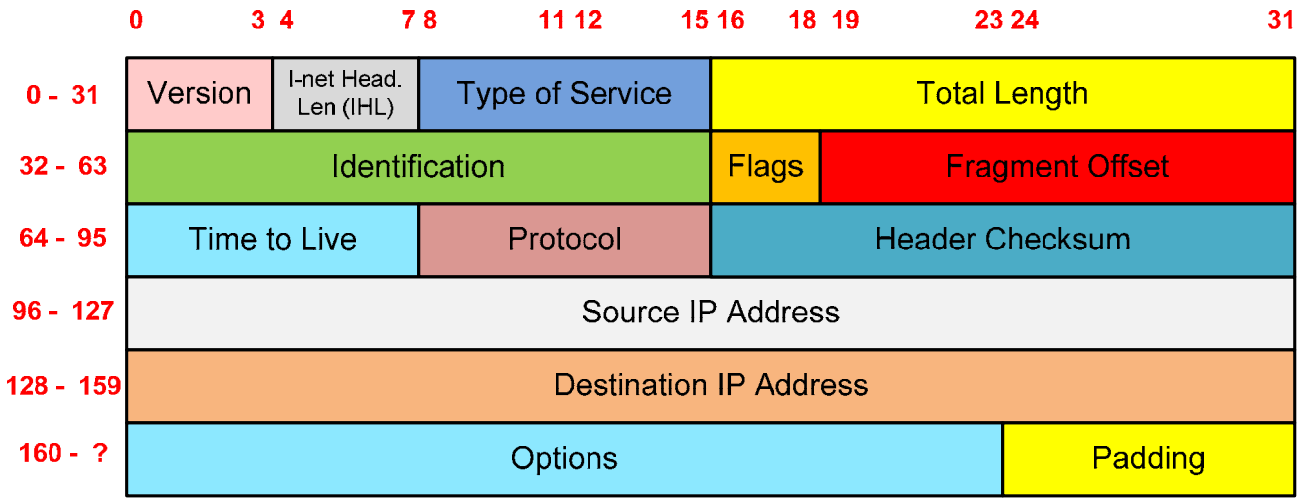
Lecture 10: TCP/IP

The Internet Protocol (IP)

The Internet Protocol (IP) is the backbone protocol of the Internet. Without it, the Internet would not have evolved to become what it is now. Nevertheless, the IP is very lousy in performing its work. It does not guarantee the delivery of packets, if they arrive, it does not guarantee that they will arrive in order, or without errors, or on time. IP packets are dropped by a router on the path to the destination if the router becomes congested, and error checking is not performed on the data (it is done only on the IP header). So, basically, you use the services of the IP protocol at your own risk. The reason for having the IP protocol's work being so lousy is that this makes it very simple and puts the complexity at the edges of the network (transfers the complexity from the network to the end machines). There are two flavors of the IP that are in use today. Internet Protocol version 4 (IPv4) is the one that is in wide use now and Internet Protocol version 6 (IPv6) which is the new standard and is now generally in its experimental phase.

IP Version 4 (IPv4) Header

The interesting part of the IPv4 protocol is its header, which adds all of the functionally that protocol performs. The header of an IP packet (version 4) is rich in components and is illustrated below:



The length of the header is always a multiple of 4 bytes (multiple of 32 bits), with a minimum length of 20 Bytes (160 bits) if no options are present in the header. Therefore, the length of the header can be 20 Bytes, 24 Bytes, 28 Bytes, … and so on. The maximum length of the header is 15*4 = 60 Bytes. What

increases the header's length beyond the minimum of 20 Bytes is a set of options that may be added the minimum header length at the end of the header. The following is a description of the different components of the IPv4 header (the length of the component is between parentheses):

- **Version (4 bits):** This is the version of the IP protocol being used which takes values of 4 (for IPv4), 5 (for some a specific type of protocols that is not important in our case), or 6 (for IPv6). So, for the following items, we will assume that the version is 4 as other versions have different header structures.

- **Internet Header Length (4 bits):** This specifies the length of the header in multiple of 4 Bytes. That is, if the header length is the minimum of 20 Bytes, this value will be 5, if the header length is 24 Bytes, this will be 6, and so on. This specifies the maximum length of the header to be 15*4 = 60 Bytes.

- **Type of Service (8 bits):** This is used to indicate specific requirements on the type of service associated with the delivery of the packet such as the priority in delivering this packet, … etc. These options are rarely used and most traffic sent over the Internet has all of these bits set to zero.

- **Total Length (16 bits):** This gives the total length (in BYTES not bits) of the packet including the header. Since this component of the header has length of 16 bits, the maximum length of the packet can be $(1111\ 1111\ 1111\ 1111)_2$ = (65535) Bytes. Therefore, the maximum data you can have in an IP packet is 65535 – 20 = 65515 Bytes (since the minimum header length is 20 bytes). However, this maximum length is rarely if ever used because most physical networks have their own maximum on the length of the frames, and since packets are encapsulated in frames the maximum size of a packet must not exceed what the frame size accepts. For example, Ethernet has a maximum of around 1500 Bytes.