The Five-Layer Network Model

What You'll Do: In your own words, describe what happens at every step of our network model, when a node on one network establishes a TCP connection with a node on another network. You can assume that the two networks are both connected to the same router.

Your submission must include a detailed explanation of the following:

- Physical layer
- Data link layer
- Network layer
- Transport layer
- MAC address
- IP address
- TCP port
- Checksum check
- Routing table
- TTL

Physical layer basically is the way to connect two devices through physical materials, like cable or light fabric. For this layer, it only care about how to pass the data, not about interpret or understand the data.

Checksum check is a tech to verify the integrity of datagram. It's been widely used in the following layers.

Data link layer is the upper layer above the physical layer. It helps device to understand the binary data (like changing voltage) sending through the physical layer. Ethernet is the most famous protocol works in this layer. It uses MAC address (which is unique for each device) to ensure data would be transferred to the intended location.

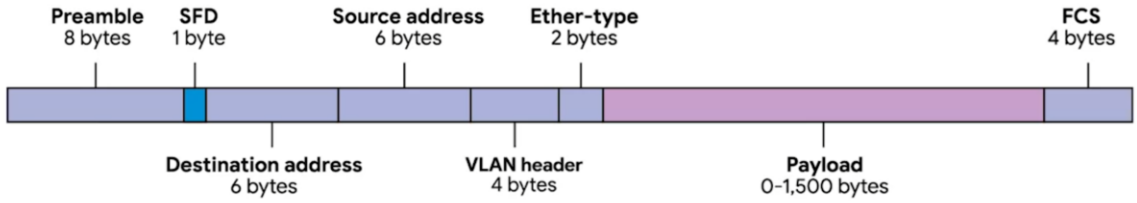

Fig 1. **Ethernet datagram**

The network layer is one upper above the data link layer. IP protocol is widely used in this layer. Notably, IP addresses belong to networks, not to any physical devices. It can be divided into two

parts originally; network ID and Host ID. Router works in this layer. And IP datagram contains Time to Live (TTL) to indicate how many routers/hops it can traverse before we throw it away.

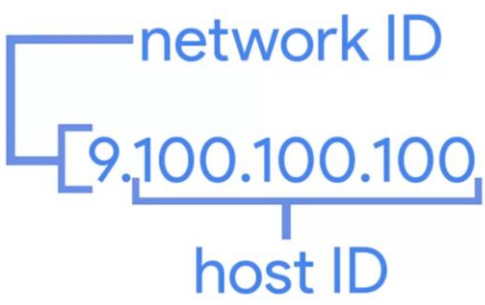

Fig 2. **IP address**

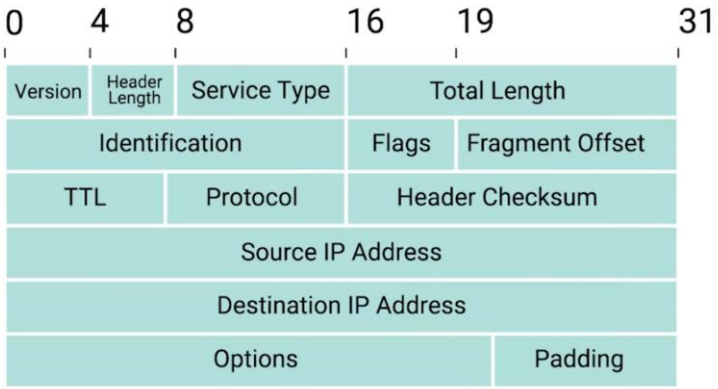

Fig 3. **IP datagram Header**

Transportation layer allows to be directed to specific network applications. TCP and UDP are most famous algorithms in this layer. When two devices use TCP protocol to build a connection, the three-way handshake is most dominant way to achieve it (shown below)

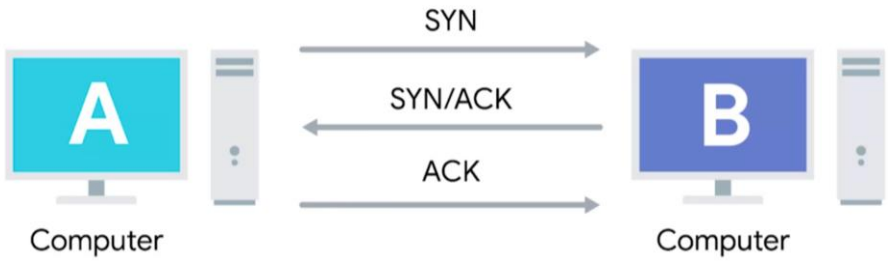

Fig 4. **The three-way handshake**

When they want to close the connection, the four-way handshake are applied.

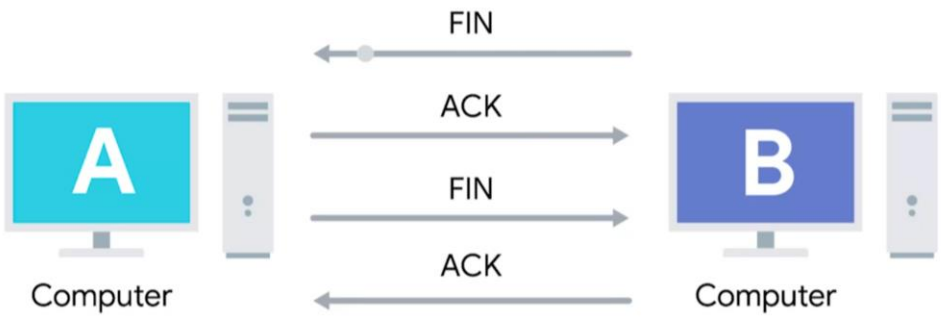

Fig 5. **The four-way handshake**

After clarifying the base concepts, let's talk about when one node (note as Computer A) from a network want to build the connection with a node (note as Computer B) from another network, what's the process:

1. Since Computer B is in another network, Computer A need to send any data to its local router to find out the local gateway for routing to a remote network
2. After getting the gateway's IP address, computer A need to find out the MAC address of the gateway. If it does not store the information locally, computer A need to broadcast the APR request to get the MAC address.
3. When get gateway's Mac Address, computer $A's$ operation system starts to build the TCP segment. First, it would detect an available local port as the source port in TCP header. And set the flag as "SYN", and auto fill the rest info needed in TCP protocol.
4. After having the TCP datagram, it would be inserted into the IP datagram as data payload and fill the Source IP and Destination IP. Usually, we use TTL as 64. And Computer A would send the IP datagram (inserted into a ethernet datagram, fills with source and destination MAC address) to the gateway.

5. There are few things need to check after the local router receive the datagram from Computer A, including address checking, checksum calculating, new checksum generating.
6. When router A looks up the IP datagram, it would find out the destination IP address does not belong to the local network. So, it would decrease the TTL by 1, and look up the APR table to find the fastest way to deliver the datagram. Then it will construct the new Ethernet datagram with network B 's MAC address as the destination.
7. Network B follows the same steps to pass the data to Router B, Router B find the source IP address is a local address, so encapsulate the new ethernet frame to Computer B
8. Computer B do the CRC (cyclic redundancy check) to confirm the integrity of data. And then it opens the TCP datagram and check the checksum, later it would verify whether there is an open socket in the destination port. If it is true, Computer B would check the control flags (which is "SYN"). Once all are right, Computer B would pack the data Computer A asked with TCP flag "SYN/ACK" with the same steps.