TCP/IP model

Layer	Protocols	Data unit	Consists of
Application	HTTP,FTP,DNS,SMTP	Application message	Data
Transport	TCP, UPD	TCP segment, UDP datagram	Data + dest. port + source port
Network	IP, ARP, ICMP	IP packet	Segment + IP dest. + IP source
Data Link	Ethernet	Ethernet Frame	Packet+MAC source+MAC router
Physical	Ethernet	Ethernet Frame	

Physical Layer

Convertes binary sequence to signals (electrical, light, radio) and transmits it within LAN cable, optical fiber cable, air.

Data Link Layer

It adds to IP packet MAC addresses of source and the first router-receiver. These addresses change when the frame forwards from router to router.

- Medium Access Control - **MAC sublayer**
  - *Data encapsulation*
    Creates a **header** and a **trailer** for IP-packet from network layer to form a frame. Header contains MAC addresses of sender and receiver. MAC address places in NIC - network interface card. It's a unique 12-symbol number. Trailer contains 4 bytes for error checking data.
  - *Accessing the media*
    CSMA/CD - Carrier Sense Multiple Access / Collision Detection. Each computer listens to the cable before sending data to the network. If a collision occurs, computers wait random amount of time and then retransmit the data.
- Logical Link Control - **LLC sublayer**
  - *Flow control*
    Restricts the amount of data. Receiver informs sender to slow down transmission rate.
  - *Error Control*
    Error detection and retransmission. Error detection is done by error checking in trailer of the frame. Retransmission is done by **Automatic Repeat Request - ARQ** - receiver sends an acknowledge to sender whether the data is damaged/lost.
  - *Sizing of packets*

  LLC functions can be done by Transport Layer.

Network Layer

It adds to a segment (datagram) IP of destination host and source host. These IP addresses never change.

- *Logical Addressing*
  Adds IP addesses of sender and receiver to TCP-segments of UDP-datagram to form an IP-packet. It ensures that each IP packet a reach the correct destination in different networks.
- *Routing*
  Send IP packets to the networks. Routing is not needed if receiver and sender are in the same network.
  Two networks are connected by a router. Computer A from network 1 needs to send data to the computer B in network 2. Network 1 has access only to MAC-addresses of devices connected to itself, it doesnt's see MAC address of computer B. Therefore, to form a frame, an ARP module take MAC address of the router R and the frame is forwarded to the router. Router finds that the MAC address in the frame matches its own MAC address and extracts IP packet from the frame and forward it to the network layer. Network layer of network 2 finds the IP of computer B and updates the frame by MAC address of B using ARP module.
- *Path determination*
  OSPF - Open Shortest Path First protocol, BGP, IS-IS.

Transport Layer

IP is unreliable. It doesn't guarantee delivery nor checking for errors.
Transport layer receives message from application layer and divides it into segments or datagrams. Also it adds ports of destination and source.

- **TCP**
  - *Connection establishment*
    Connection request, ACK, ACK - Three-Way handshake
  - *Error free data transfer*
    Calculating check-sum. If check-sum is different, receiver doesn't send ACK to sender, so sender retransmits segment.
  - *Ordered data transfer*
  - *Retransmisssion of lost data*
  - *Discarding duplicate packets*
  - *Congestion (flow) control*
    The goal is to send segments as fast as possible not losing them. Sender sets a timer. If sender receives ACK before the timer expires, it increases the transmission speed. If ACK of some segment isn't received in time, the sender retransmits the segment. If a significant number of retransmissions is done, the sender slows down transfer speed.
  - *Connection termination*
    Finished, ACK, finished, ACK - Four-Way handshake

Application Layer

We need to know which application process has to receive a segment from transport layer. That's why data segment contains ports of source and destination.