- ❖ Computer networks are built on the basis of various environments and facilitate the exchange of data between computing devices.
- ❖ The OSI (Open Systems Interconnection) Basic Reference Model: determines the interaction of network nodes and the functions of each specific layer.
- ❖ The OSI Model Layers:
  - o Physical: describes the physical and electronic data transmission medium. Also responsible for:
    - ▪ The transmission process of individual data bits.
    - ▪ The electrical parameters of signals, such as amplitude and frequency.
    - ▪ Types of wires and Connector.
    - ▪ Network topology and connection of devices.
    - ▪ Protocols: (EIA R2-232), (RS-485), (100BASE-T)
  - o Data Link: the generated bits are packaged and transmitted via the network in what are known as data frames. Also responsible for:
    - ▪ The integrity of frame delivery and error checking.
    - ▪ The identification of a device's unique physical address (MAC Address) on the network and the logical topology of the network
    - ▪ Data transmission synchronization
    - ▪ Protocols: Point-to-Point Protocol (PPP)

The diagram below shows an example of an 802.3 standard Ethernet frame.
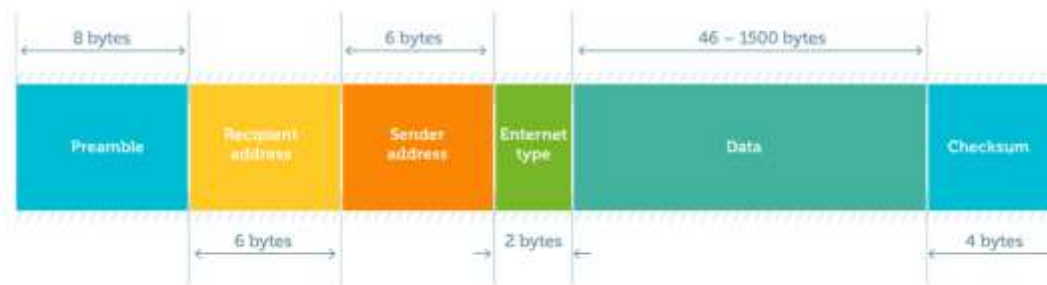
- o <u>Network</u>: responsible for data transmissions between multiple networks. Also responsible for:
    - Identifying the shortest routes for the transmission of data (routing)
    - network performance
    - Flow control:
        - Example: make sure that the sender is not transmitting messages faster than the recipient can process them.
- o <u>Transport</u>: handles the transmission of packets via the communication network. Also responsible for:
    - Packet segmentation.
    - Ensuring the reliability and correct sequence of packet transmission.
    - Processing errors when delivering messages.
- o <u>Session</u>: responsible for establishing and maintaining communication sessions between devices and ensuring their proper termination:
- o <u>Presentation</u>: responsible for data conversion: coding, encryption and/or compression into the format required by the application.
- o <u>Application</u>: responsible for the interaction of user applications with the network and creating a network interface between end devices when transmitting data via the network.

- ❖ TCP/IP Model: used in real computer networks and was developed on the basis of protocols actually used.
  - ○ Data Link: combines the physical and data link layers of the reference model, separately describing the physical environment and data transmission frames
    - ▪ Ethernet (IEEE 802.3): uses a shared bus topology, to prevent collisions, it supports the Carrier Sense Multiply Access with Collision Detection (CSMA/CD) protocol.
    - ▪ Wi-Fi (802.11): the Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) network protocol is the same as CSMA/CD for the set of 802.11 wireless standards.
    - ▪ Bluetooth (IEEE 802.15): Network devices such as switches and network bridges operate at the data link layer to transfer data within the same local network.
  - ○ Network: deliver packets from sender to recipient, where delivery can occur in several subnets. (same as in OSI model)
    - ▪ IP (Internet Protocol): transfers blocks of data called datagrams between devices with addresses specified as IP addresses
    - ▪ ARP (Address Resolution Protocol): convert the IP addresses of network nodes into the physical MAC addresses of the corresponding network adapters.
    - ▪ ICMP (Internet Control Message Protocol): uses special packets to inform network nodes about packet delivery failure, packet expiry, etc.
    - ▪ Routers operate on this layer which forward packets between different network segments based on rules and routing tables.

- o <u>Transport</u>: responsible for transmitting data between different application processes.
  - Uses ports to allow packets to be exchanged between applications rather than just nodes:
    - Port is a 16-bit natural number from 1 to 65535. All ports can be divided into three groups:
      - o Well-known or system ports (0-1023)
      - o Registered or user ports (1024-49151)
      - o Dynamic or private ports (49151-65535)
  - TCP (Transmission Control Protocol):
    - A reliable protocol that ensures data delivery
    - Responsible for segmenting, ordering, and eliminating duplicate data segments, as well as monitoring errors and the transmission rate.
    - Uses a three-way handshake to establish a reliable connection.
  - UDP (User Datagram Protocol):
    - Information can be transmitted without first establishing a connection between the sender and receiver
    - Faster but less reliable as some data fragments may be lost or delivered out of order during transmission.
- o <u>Application</u>: combines the functions of all three (session, presentation, application) layers and move them to a separate application layer.
  - Domain Name System (DNS): retrieves information about domains, in particular about the IP addresses of a particular host.
  - Hypertext Transfer Protocol (HTTP): allowing browser to load web pages.
  - Telnet (Teletype Network)
  - Secure Sockets Layer (SSL)
  - Secure Shell (SSH)
  - File Transfer Protocol (FTP)
  - Dynamic Host Configuration Protocol (DHCP)
  - Simple Mail Transfer Protocol (SMTP)
- ❖ The MAC address sets the unique identifier of network equipment or a network port as 6 octets (48 bits).

- ❖ <u>IPv4</u>: represents all IP addresses as 4 bytes (32 bits) separated by a period (.)
  - o Classful:
    - ▪ Addresses divided into 5 classes: A, B, C, D, E.
    - ▪ D and E are reserved for special services.

Address class	Network(N) and host (H) address parts	Default subnet mask	Number of possible networks and network nodes
A	N.H.H.H	255.0.0.0	128 networks 16,777,214 nodes
B	N.N.H.H	255.255.0.0	16,384 networks 65,534 network nodes
C	N.N.N.H	255.255.255.0	2,097,150 networks 254 network nodes

  - o Classless:
    - ▪ Class addressing has been replaced by Classless Inter-Domain Routing (CIDR), which allocates the IP address space more economically and flexibly.
    - ▪ CIDR is based on a variable length subnet mask that specifies the range of resolvable IP addresses
      - • Example: an IP address in CIDR notation is written as 192.168.110.0/24, where /24 is the same as the mask 55.255.255.0. This /24 mask allows for an IP address range from 192.168.110.1 to 192.168.110.254 on the subnet.

- o Public addresses:
    - Used to remotely access websites, internet services, webcams, applications, and more online.
- o Private addresses:
    - Used on local networks and nobody controls their allocation.

1 From 10.0.0.0 to 10.255.255.255 with mask 255.0.0.0 or /8

2 From 172.16.0.0 to 172.31.255.255 with mask 255.240.0.0 or /12

3 From 192.168.0.0 to 192.168.255.255 with mask 255.255.0.0 or /16

4 From 100.64.0.0 to 100.127.255.255 with mask 255.192.0.0 or /10

❖ IPv6:

FE80 : 0000 : 0000 : 0000 : 1926 : 4D5F : 14F2 : 8600

48 bit	16 bit	64 bit
Global routing prefix	Subnet ID	Interface ID

128 bit IPv6 address