ACADEMIC PROGRAMME: BACHELOR OF SCIENCE IN COMPUTER SCIENCE
COURSE CODE AND TITLE: BSCS 302 – DATA COMMUNICATION AND NETWORKS
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Data Communication Network

Brief History of Computer Networks

• 1960's – "How can we transmit bits across a communication medium efficiently and reliably?"

• 1970's – "How can we transmit packets across a communication medium efficiently and reliably?"

• 1980's – "How can we provide communication services across a series of interconnected networks?

• 1990's – "How can we provide high-speed, broadband communication services to support high-performance computing and multimedia applications across the globe?"

Internet History: Other Goals

- Survive hardware failure
- Support multiple types of applications
- Run on wide variety of networks
- Distributed management of resources
- Cost-effective

COMMON COMMUNICATION TASKS

Data encoding*:* the process of transforming input data or signals into signals that can be transmitted

Signal generation*:* generating appropriate electro-magnetic signals to be transmitted over a transmission medium

Synchronization*:* timing of signals between the transmitter and receiver ; when a signal begins and when it ends; duration of each signal

Error detection and correction*:* ensuring that transmission errors are detected and corrected

Flow control: ensuring that the source does not overwhelm the destination by sending data faster than the receiver can handle

Multiplexing*:* a technique used to make more efficient use of a transmission facility. This technique is used at different levels of communication

Addressing: indicating the identity of the intended destination

Routing: selecting appropriate paths for data being transmitted

Message formatting*:* conforming to the appropriate format of the message to be exchanged

Security: ensuring secure message transmission

Systems management: configuring the system, monitoring its status, reacting to failures and overloads, and planning for future growth

A communication network is a collection of devices connected by some communications media

- Example devices are:
    - mainframes, minicomputers, supercomputers
    - workstations, personal computers
    - printers, disk servers, robots
    - X-terminals
    - Gateways, switches, routers, bridges , brouters
    - Cellular phone, Pager.
    - Refrigerator, Television, Video Tape Recorder
- Communications Media
    - twisted pairs
    - coaxial cables
    - line-of-sight transmission: lasers, infra-red, microwave, radio

- satellite links
- fiber optics
- Power line

Computer Communication Architecture

• Computer Communication – the exchange of information between computers for the purpose of cooperative action

• Computer Network – a collection of computers interconnected via a communication network

• Protocol – agreement required between the communication entities and consists of three components:

Syntax: data format and signal levels

Semantics: control information for coordination and error handling

Timing: speed matching and sequencing

• Communications Architecture – a structured set of modules that implements the communication function

NETWORK INFRASTRUCTURE

A computer network is made of

 D**istributed applications**

  provide services to users on other machines, or to other machines

  execute on computers

 Network infrastructure

  supports transport of data between computers where distributed applications reside

  in computers (Ethernet card, modem + software)

  + in special network devices (bridges, routers, concentrators, s witches)

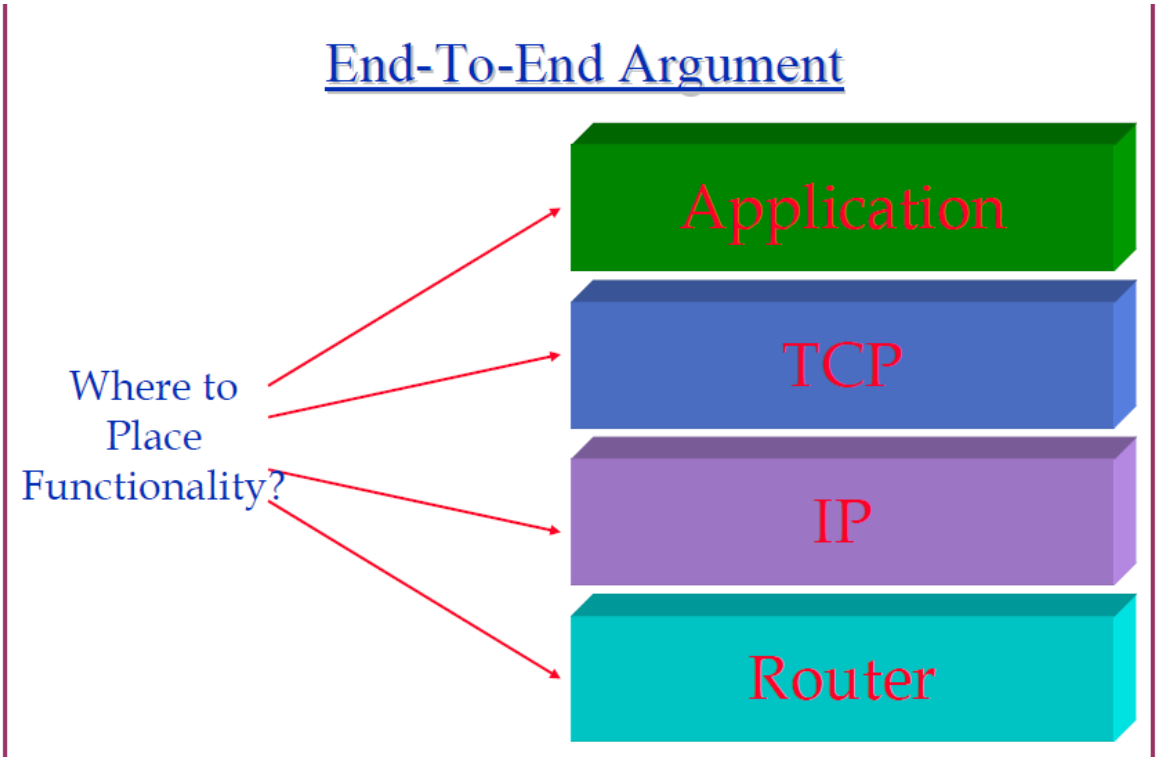
A computer network is made of two distinct subsets of components

- **distributed applications** are programs running on interconnected computers; a web server, a remote login server, an e-mail exchanger are examples.

- **the network infrastructure** is the collection of systems which are required for the interconnection of computers running the distributed applications.

Challenges To Achieving Universal Communication

- ✓ How to connect computers
  - • Cannot have all-to-all connections
- ✓ How to *name* and *locate* computers
  - • Billions of computers: translate name into physical location
- ✓ Routing
  - • Transmitting messages from one computer to another
- ✓ Software/Protocols
  - • Not just send messages, must agree on format and interpretation
- ✓ Reliability
  - • Networks drop, corrupt, and reorder messages
- ✓ Common challenge is scalability



End-to-End Argument

Functionality should be implemented at a lower layer if and only if it can be correctly and completely implemented there

- Should not be implemented at lower level if redundant with higher level
- Performance optimizations are not a violation
- Want to know if host acted on the request not whether it received it

What should be done at the end hosts, and what by the network?

- Addressing/routing?
- Reliable delivery?
- Sequenced delivery?
- Congestion control/resource allocation?
- Real-time guarantees?
- Security?
- Multicast?

PROTOCOLS AND STANDARDS

PROTOCOLS

- A protocol is a set of rules that govern data communications.
- A protocol defines **what** is communicated, **how** it is communicated, and **when** it is communicated.
- The key elements of a protocol are syntax, semantics, and timing.

STANDARDS

Standards are essential in creating and maintaining an open and competitive market for equipment manufacturers and in guaranteeing national and international interoperability of data and telecommunications technology and processes.

LAYERED ARCHITECTURE

• A network needs to provide communication between one application program on one end system and another application program on another end system.

• There is a need for harmony between:

– Application programs

– End systems (e.g. computer stations)

– Intermediate systems (e.g. routers)

– Transmission media (e.g. Ethernet, Token Ring)

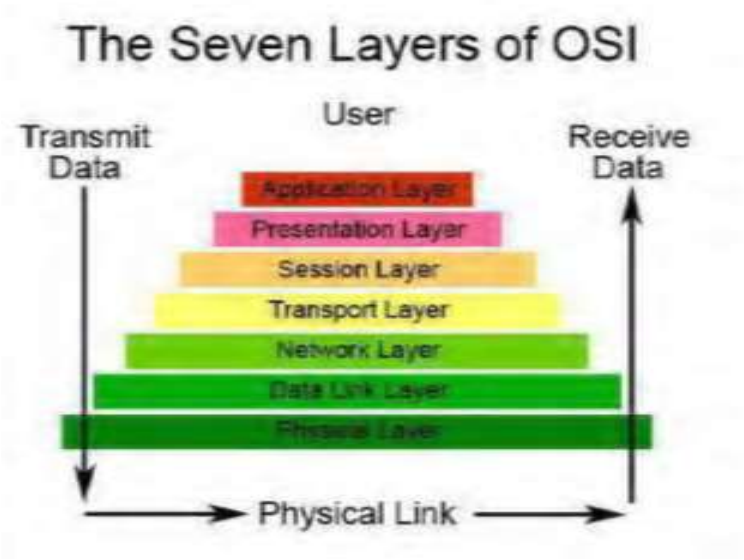
• The task of networking is very complex due to the fact that some part of the systems should handle a subset of the task and others another subset (e.g. media, routers).

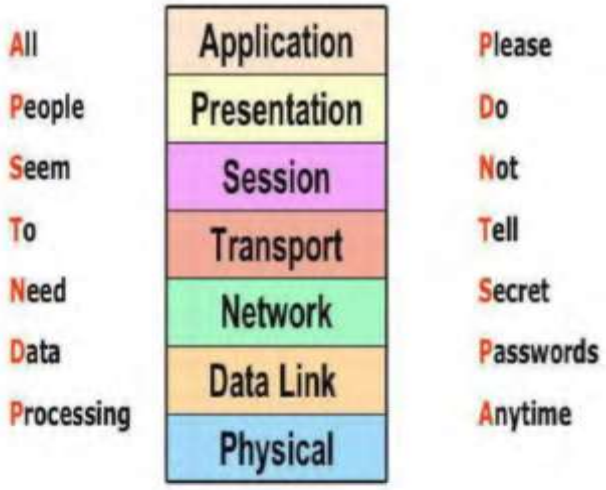
• In a layered architecture the complex task of communication between two applications is broken into layers.

OSI MODEL

- Its the Open Systems Interconnection (OSI) architecture.

- This 7 layer model defines a partitioning of network functionality into seven layers, where one or more protocols implement the functionality assigned to a given layer.





DESCRIPTION

A set of layers and protocols is called network architecture. It refers to the logical and physical design of a network.

- The OSI model is composed of seven ordered layers: physical (layer 1), data link (layer 2), network (layer 3), transport (layer 4), session (layer 5), presentation (layer 6) and application (layer 7).
- The above figure shows the layers involved when a message is sent from device A to device B. As the message travels from A to B, it may pass through many intermediate nodes.

- Within a single machine, each layer calls upon the services of the layer just below it. Layer 3, for example, uses the services provided by layer 2 and provides services for layer 4. Between machines, layer x on one machine communicates with layer x on another machine.
- This communication is governed by an agreed-upon series of rules and conventions called protocols.
- The processes on each machine that communicate at a given layer are called peer-to-peer processes. Communication between machines is therefore a peer-to-peer process using the protocols appropriate to a given layer.

Benefits/main purpose

- An open system is a set of protocols that allows any two different systems to communicate regardless of their underlying architecture.
- The purpose of the OSI model is to show how to facilitate communication between different systems and interoperable without requiring changes to the logic of the underlying hardware and software.
- it is a model for understanding and designing a network architecture that is flexible, robust, and interoperable.
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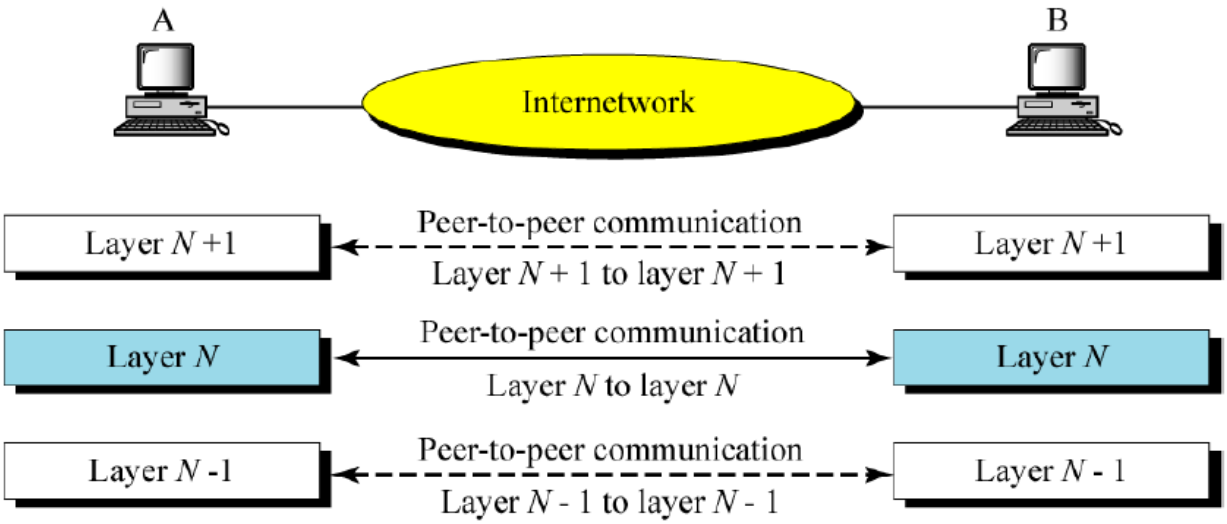
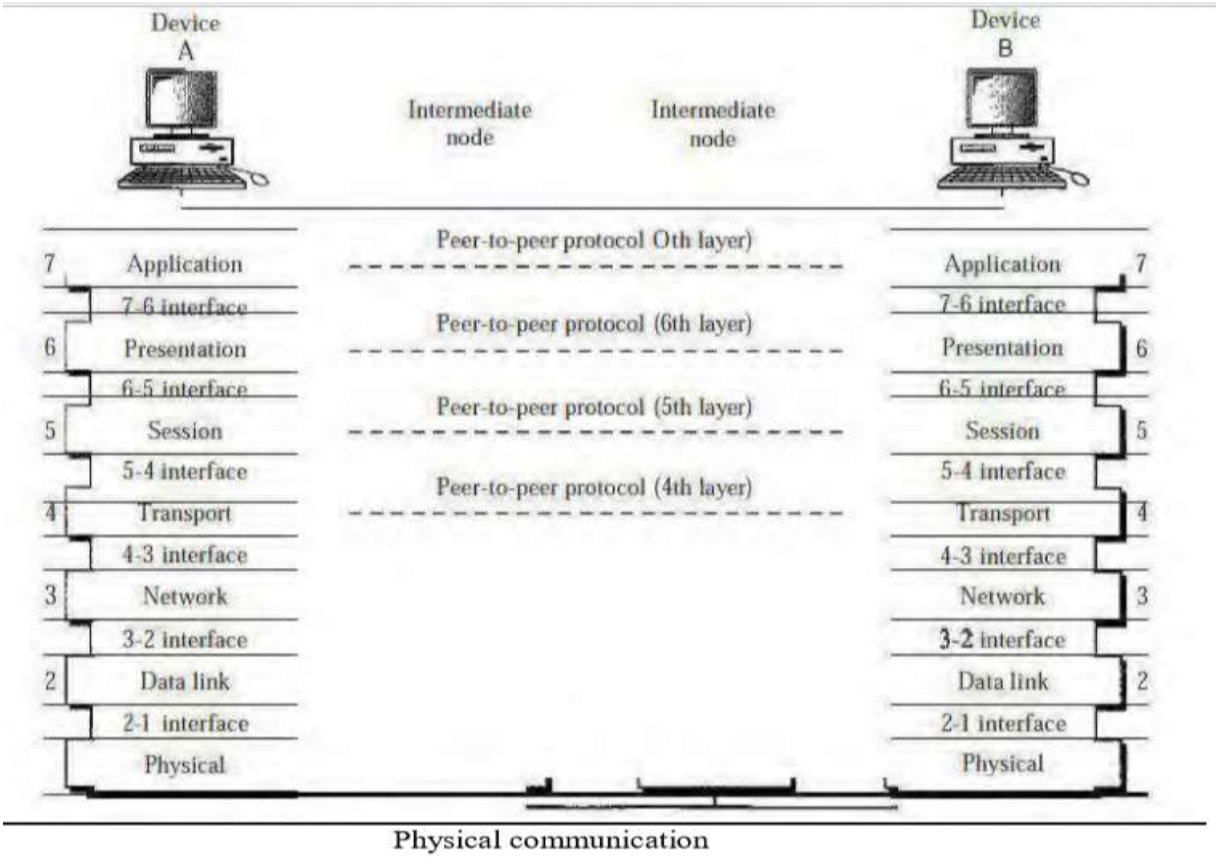
PEER-TO-PEER COMMUNICATION

• In a layered architecture, each given layer in one system logically communicates with its corresponding layer at the other system.
• The communication between two corresponding layers requires a common unit of data (packet) called a protocol data unit (PDU) be defined – the PDU used at layer N is called N-PDU.

Peer-to-Peer Communication



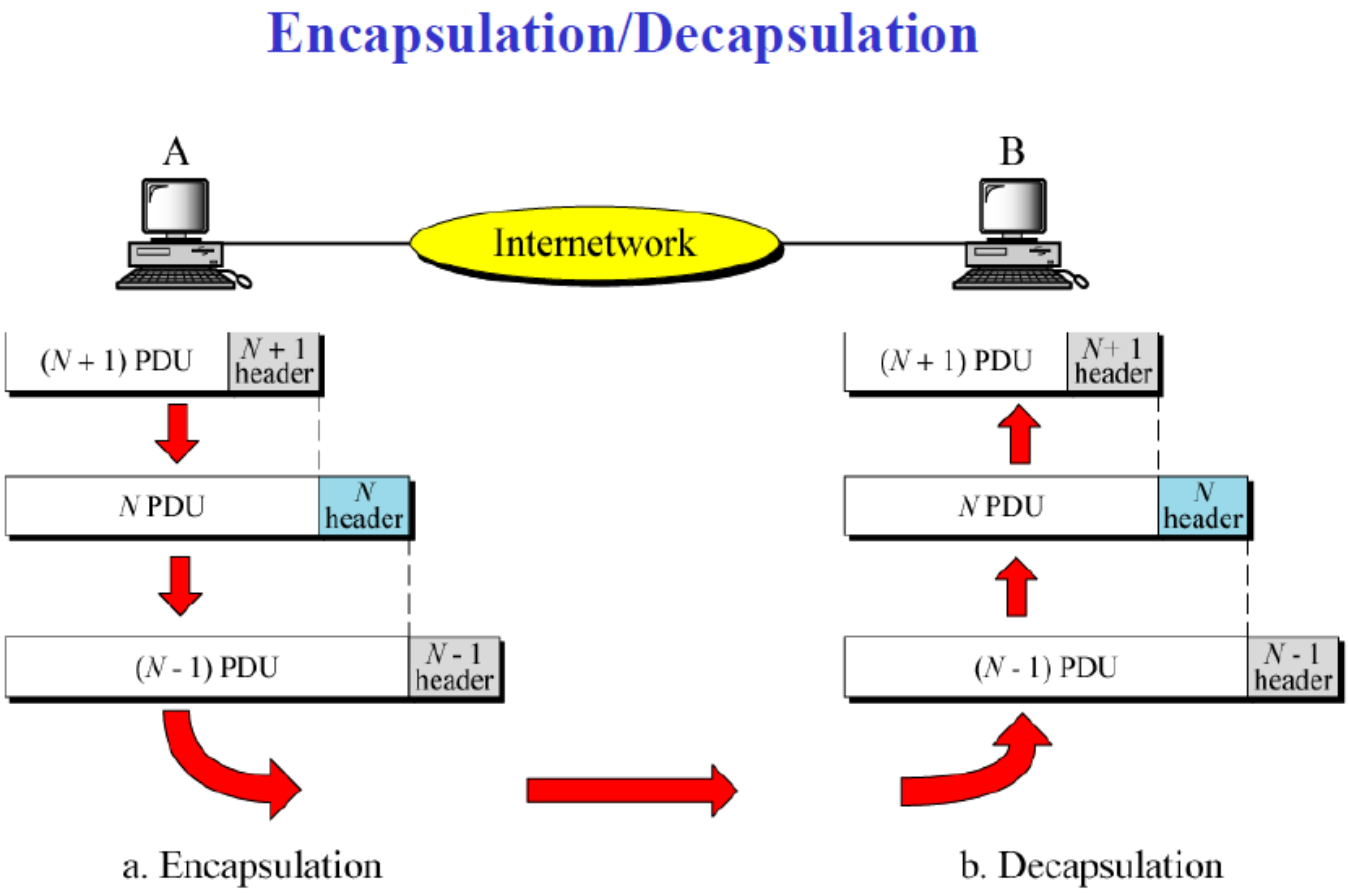


Encapsulation / Decapsulation

• At the source the data flows downward while at the destination the data flows upward.

• Headers or trailers are added to or removed from the PDU delivered by upper or lower layers – a process called encapsulation or decapsulation.

• In a multilayer protocol, layer N receives services from layer N-1 and gives services to layer N+1.



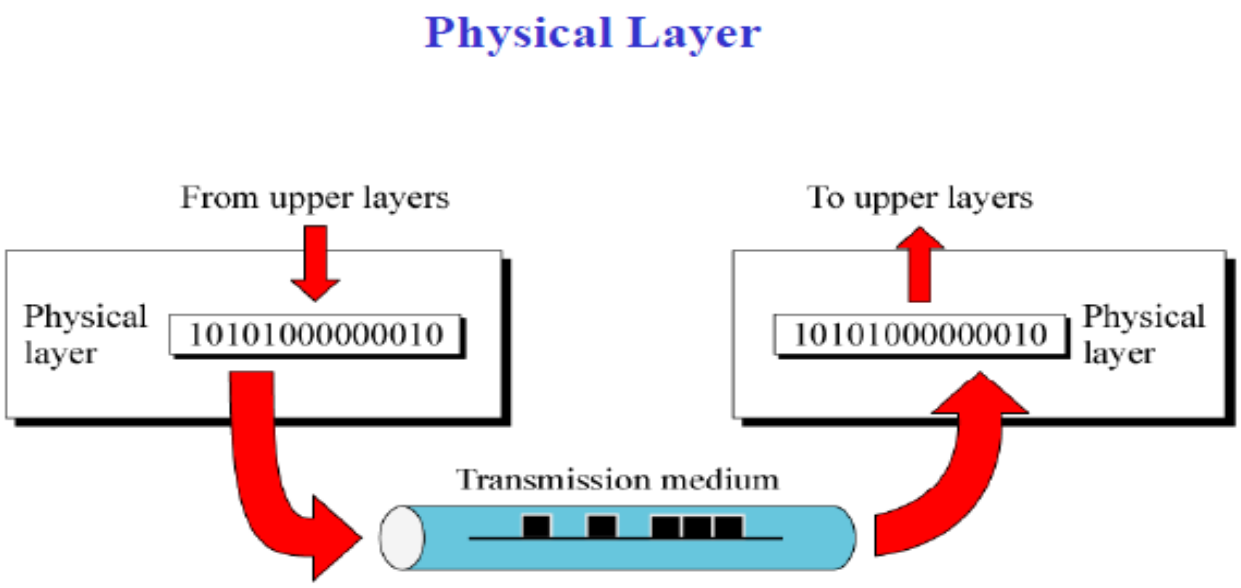
FUNCTION OF EACH LAYER IN OSI MODEL

PHYSICAL LAYER

- It deals with the mechanical and electrical specifications of the interface and transmission medium.
- The physical layer coordinates the functions required to create a bit link (i.e. a physical connection) between the sender and receiver.

• It is concerned with the following:

– Representation of bits: analog, digital …
– Data rate: # of bits sent per second (bps)
– Bit synchronization: self-synchronizing encoding …
– Characteristics of interfaces: system to media connection
– Transmission medium: cable, fiber optic, air …
– Transmission mode: simplex, half-duplex, full-duplex



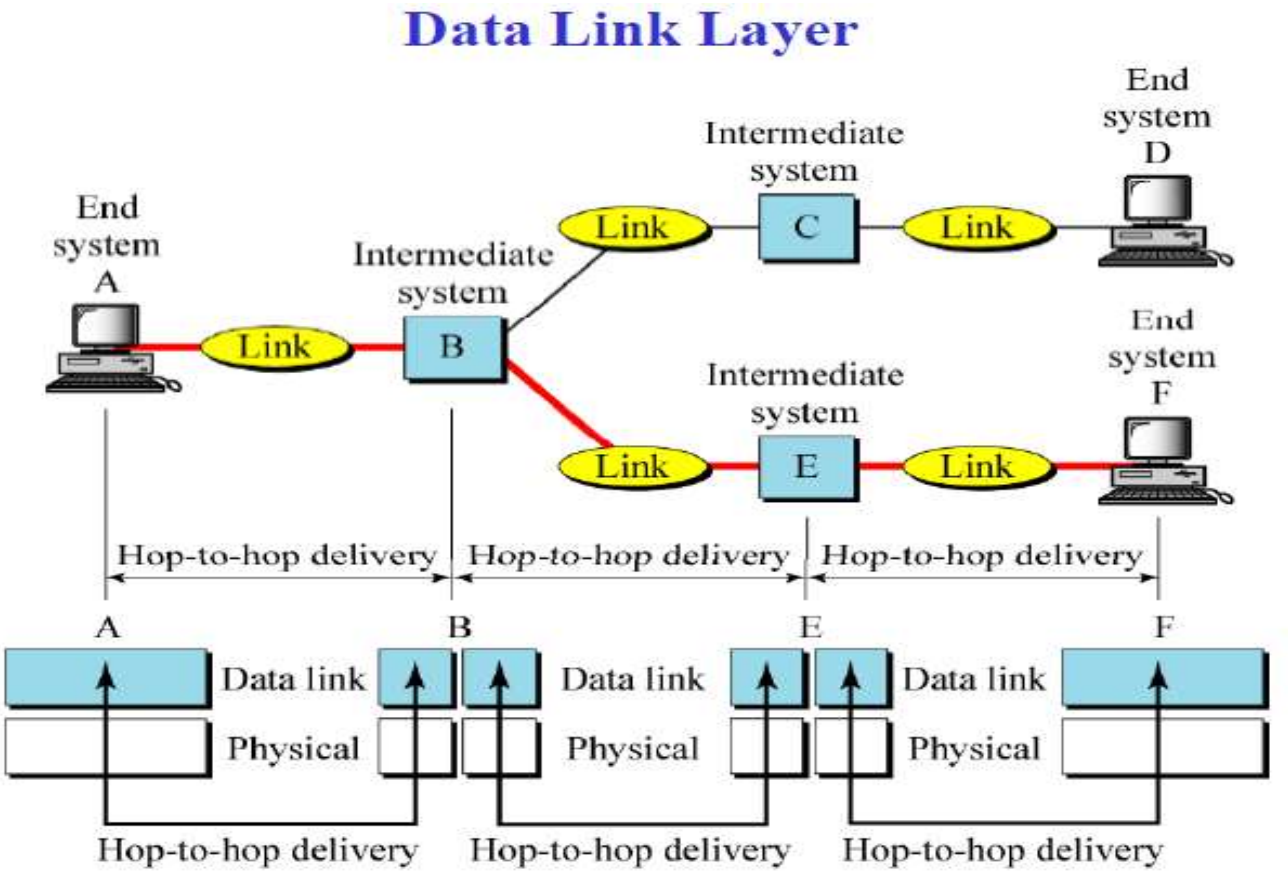
DATA LINK LAYER

It responds to service requests from the network layer above it and issues service requests to the physical layer below it.

The data link layer is divided into two sub layers: the media access control (MAC) layer and the logical link control (LLC) layer.

Responsibilities:

- Framing: The data link layer divides the stream of bits received from the network layer into manageable data units called frames.
- Physical addressing
- Flow control
- Error control: The data link layer adds reliability to the physical layer by adding mechanisms to detect and retransmit damaged or lost frames.



NETWORK LAYER

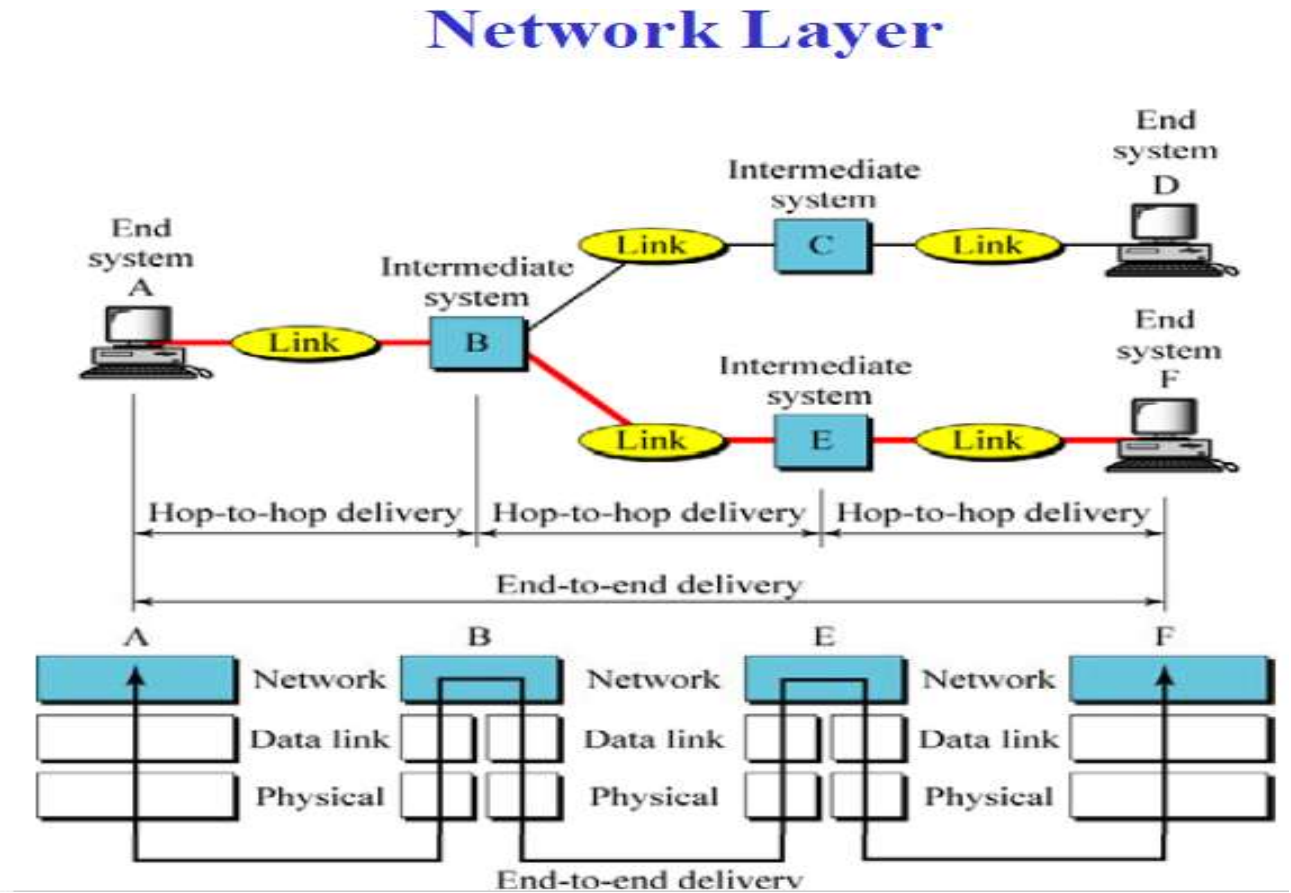
- The network layer is responsible for the source-to-destination delivery of a packet across multiple networks (links).

- Whereas the data link layer oversees the delivery of the packet between two systems on the same network (links). The network layer ensures that each packet gets from its point of origin to its final destination.
- Creating a logical end-to-end connection – the two end systems should see a logical connection without worrying about links and their connecting devices.

Other responsibilities of the network layer include the following:

- **Logical addressing**: The physical addressing implemented by the data link layer handles the addressing problem locally. If a packet passes the network boundary or nodes located in other network then, we need logical address to distinguish the source and destination systems.

- **Routing.** Routing means finding suitable path to forward the message.



TRANSPORT LAYER

- The transport layer is responsible for process-to-process delivery of the entire message. A process is an application program running on a host.

- The network layer gets each packet to the correct computer where the transport layer gets the entire message to the correct process on that computer.
- It is also responsible for end-to end communication
- Involved in Segmentation and reassembly: A message is divided into transmittable forms called segments.
- Flow control and error control
- Connection control
    - Connectionless: each segment is an independent packet and is delivered to the transport layer at the destination separately
    - Connection-oriented: a connection must be established between the source and destination transport layers before delivering the packets

SESSION LAYER

• It provides the control structure for communication between applications, and establishes, manages and terminates connections (sessions) between cooperating applications.

• A session is a persistent logical linking of two software application processes, to allow them to exchange data over a prolonged period of time.

- The session layer tracks connections, also called sessions.
- The Session layer also provides dialog control between devices, or nodes.

PRESENTATION LAYER

 The presentation layer is primarily concerned with the syntax and semantics of the information exchanged between two systems.

 Presentation layer takes care that data sent in such a way the receiver will understand the data and will able to use.

The functions involved include:

- **Translation:** Because different computers use different encoding systems, the presentation layer is responsible for interoperability between these different encoding methods.
- **Encryption:** Encryption means that the sender transforms the original information to another form and sends the resulting message out over the network.
- **Compression:** Data compression reduces the number of bits contained in the information.

APPLICATION LAYER

- It provides user interfaces and support for services such as electronic mail, remote file access and transfer, shared database management, and other types of distributed information services.
- The OSI application layer is responsible for displaying data and images to the user in a human-recognizable format.
- Some examples of application layer protocols include HTTP, FTP, SMTP, NFS (network file access), Telnet, SNMP(network management), POP3 and IRC (online chat).

Summary of Layer Functions