CCN: Networks Software Model

Dr. E.SURESH BABU
Assistant Professor
Computer Science and Engineering Department
National Institute of Technology, Warangal.
Warangal, TS, India.

Goals:

- Networks Software Model
- Layering Concept
  - ✓ Open System Interconnection
    - Specific Responsibilities of each layer
  - ✓ TCP/IP Reference Model
- Comparison OSI and TCP/IP
- Analyzing the TCP/IP Using Wireshark (Active Learning)

Data Communication

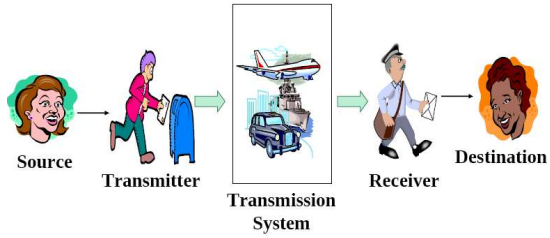
Network Technology

- Network Technology is coordinated with set of software and hardware
  - ✓ For Example: Drivers, Network adapters, Cables and Connectors
- Mechanism of Data transmission across the communications links

Data Communication

- Direct communication is exchange of data between two or more devices via some transmission medium
- Transmission medium between devices : Medium through Which we transmit our data.
  - ✓ Eg. Transmission of data from laptop to PC via cable, wireless etc.

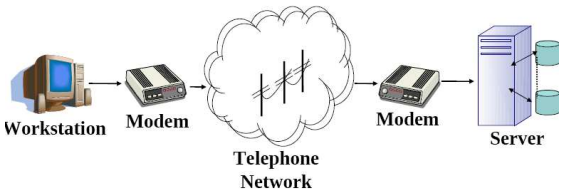
Physical Communication Model



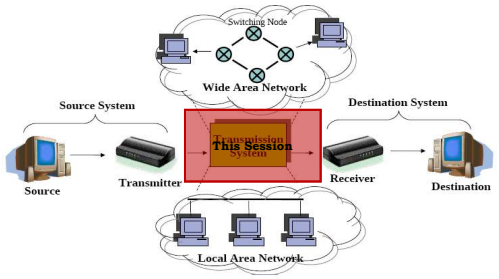
Physical Communication Model

- Communication Model has five components
  - ✓ Source : Generates the data to be transmitted
  - ✓ Transmitter : Converts data into transmittable signals
  - ✓ Transmission system : Carries the data
  - ✓ Receiver : Converts the received signals into data
  - ✓ Destination : Accepts the incoming data.

Electronics Communication Model

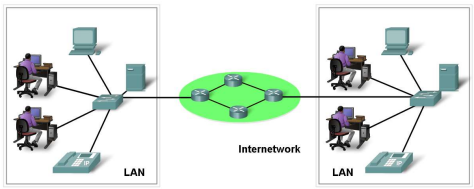


Network Model



Communication Technology

- All computer networks are in widespread use based on **Scaling.**



Scaling on Communication Technology

- The another criteria for classifying of computer networks is **scale.**
- They are divided into **three categories:**
  1. **Local Area Network (LAN).**
  2. **Metropolitan Area Network(MAN).**
  3. **Wide Area Networks (WAN).**

Networks Software Model

- Computer Networks is a **very complex systems** with many "pieces"
  - ✓ **Hosts,**
  - ✓ **Routers,**
  - ✓ **Links of various media,**
  - ✓ **Applications,**
  - ✓ **Protocols,**
  - ✓ **Hardware, Software etc.** which needs a **Overall Plan**

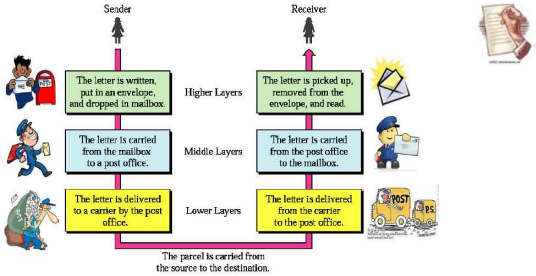
Networks Software Model

- Overall Plan of Computer Networks requires an **Architecture**
- Network Architectures define the
  - ✓ Standards and techniques for designing and building communication systems for computers and other devices.

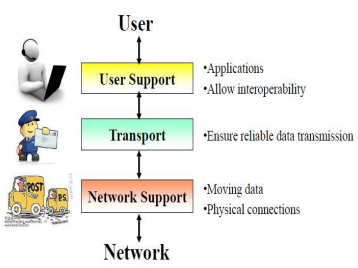
Basic Concept of Layering

- To reduce the design complexity and to flexible implementation, the concept of layering is introduced
  - ✓ Most computer networks are organized as a Stack of Layers

Layering Task involved in sending a letter



Layering Task



Layering Concept

Layering System

- Layering System provides
  - ✓ Modularity and Abstracts out of implementation details.
  - ✓ Enables different components and implemented independently.
  - ✓ Changes in one layer does not necessarily changes in other layers.
  - ✓ Once a certain service is implemented,
    - ➢ Several upper layer programs may use the same service.

Network Architecture

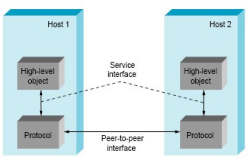
- The basic idea of a **layered architecture** is to divide the design into small pieces called **Layers.**
- A set of layers, protocols and interfaces between two consecutive layers is known as **network architecture**

Layering Architecture

- The basic elements of a **layered model** are
  - ✓ **Services,**
  - ✓ **Protocols** and
  - ✓ **Interfaces.**

Services, Protocols and Interfaces...

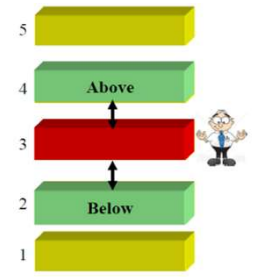
- Interfaces are defined between the layers that provides the service.
  - ✓ The messages from one layer to another are sent only through interfaces.
- Two modules in the same layer on distinct network entities, that communicate with each other are referred to as **peers.**



Layering Architecture

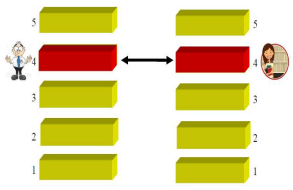
- Interfaces between layers (Physical)
- Peer-to-Peer process (Logical)

Interfaces between layers (Physical)



What is Peer-to-Peer Communication

- Two modules in the same layer on distinct network entities, that communicate with each other are referred to as **peers.**

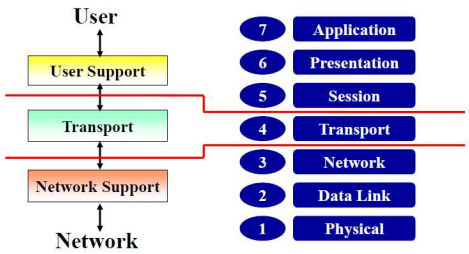


Open System Interconnection (OSI) Reference Model

Open System Interconnection(OSI) Reference Model

- The OSI reference model is a layered architecture developed by
  - ✓ **International Standards Organization(ISO).**
  - ✓ which as an international standard for data networks
- The OSI reference model has a clean structure that helps in the understanding of layering.

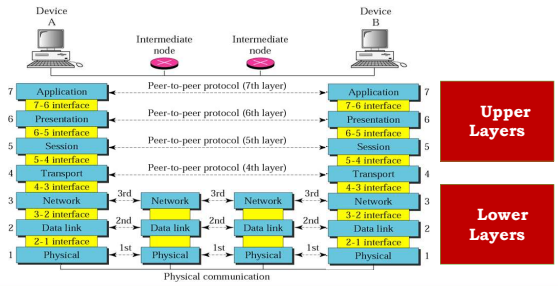
Open System Interconnection (OSI) Reference Model



Open System Interconnection(OSI) Reference Model

- The OSI model is a framework into which the various networking standards can fit.
- The OSI model specifies
  - ✓ what aspects of a network's operation can be addressed by various network standards.
- Finally, the OSI model is sort of a standard of standards.

Open System Interconnection (OSI) Reference Model



OSI Model: Conceptual Picture

- The first three layers are sometimes called the **lower layers.**
  - ✓ They deal with the mechanics of how information is sent from one computer to another over a network.
- Layers 4 through 7 are sometimes called the **upper layers.**
  - ✓ They deal with how applications programs relate to the network through application programming interfaces.

Layers of the OSI model

Physical Layer : Transmission/reception of raw bits

Data Link Layer : Maps bits into frames, dictates sharing of common medium, corrects/detects errors , re-orders frames

Network Layer :Routes packets to destination, may perform fragmentation and re-assembly.

Transport Layer: Flow (congestion) control, error control, transparent transport to upper layers

Layers of the OSI model

Session Layer : Establishes connection among hosts, duplex, half duplex, graceful connection termination, combination of streams

Presentation Layer : Negotiation of format of data exchanged between hosts

Application layer: Application services such as FTP, X.400 (mail), HTTP

Layers of the OSI model

7	Application	User service
6	Presentation	Translate format, encrypt
5	Session	Session manage, checkpoints
4	Transport	Reliable end-to-end (whole message)
3	Network	Packet end-to-end (across network)
2	Data Link	Node-to-node (same network segment)
1	Physical	Physical

Physical Layer

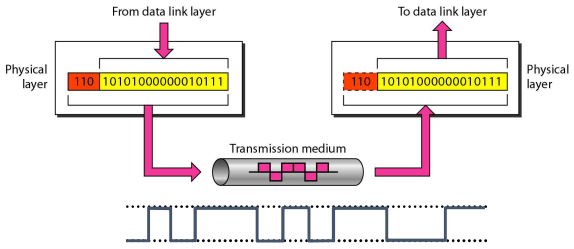
Specific Responsibilities: Physical Layer

- **Representation of bits:** 0/1 encoded into signals (electrical or optical)
- **Data Rate:** duration of a bit, how long a bit lasts
- **Synchronization of bits:** synchronization at the bit level
- **Line configuration:** point-to-point or multipoint
- **Physical Topology:** mesh, star, ring, or bus
- **Transmission Mode:** simplex, half-duplex, or full-duplex

Physical Layer

- The Bottom layer of the OSI model is the **Physical layer.**
- The physical layer is concerned with transmission of raw bits over a communication channel.
  - ✓ It specifies the mechanical, electrical and procedural network interface specifications and
  - ✓ The physical transmission of bit streams over a transmission medium connecting **two pieces of communication equipment (Topology).**

Physical Layer



Physical Layer

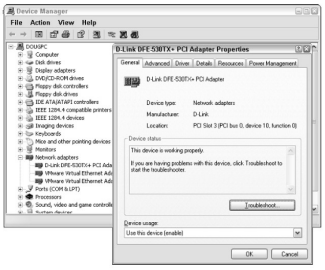
- **Physical layer** addresses the physical characteristics of the network
  - ✓ Types of cables used to connect devices,
  - ✓ The types of connectors used,
  - ✓ How long the cables can be and so on.
- The star, bus, ring, and mesh network topologies are used in the Physical layer.

Physical Layer

- Physical layer also deals with the electrical characteristics of the signals used
  - ✓ To transmit data over the cables from one network node to another.
- The Physical layer doesn't define any meaning to those signals other than the **basic binary values of zero and one.**
- The higher levels of the OSI model must assign meanings to the bits that are transmitted at the Physical layer.

Network Adaptors(NIC) Properties

- The *network adapter* (also called a *network interface card* or *NIC*) that's installed in each computer on the network is a Physical layer device



Layers of the OSI model

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Data Link Layer

Specific Responsibilities: Data Link Layer

- Layer 2 is Responsible of:
  - ✓ Moving frames from one hop (node) to the next.
  - ✓ **Framing:** divided the stream of bits received from the network layer manageable data units called frames.
  - ✓ **Physical address (MAC address).**
  - ✓ **Flow control.**
  - ✓ **Error control:** added trailer to the end of frame.
  - ✓ **Access control.**
  - ✓ **Hop-to-Hop** (node-to-node).

Data Link Layer

- The Data Link layer is the lowest layer at which **meaning is assigned to the bits** that are transmitted over the network.
- Data link layer provides service to the Network layer.
  - ✓ The network layer wants to be able to send packets to its neighbors without worrying about the details of getting it there in one piece.

Data Link Layer

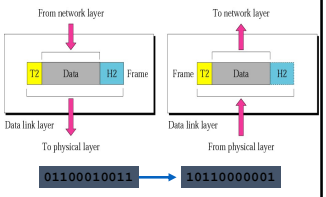
- Data link protocols address things
  - ✓ Size of each packet of data to be sent,
  - ✓ The address of each packet so that it's delivered to the intended recipient.

Data Link Layer

- **Error control protocol** returns a positive or negative acknowledgment to the sender.
  - ✓ A positive acknowledgment indicates the frame was received without errors,
  - ✓ While a negative acknowledgment indicates the opposite.

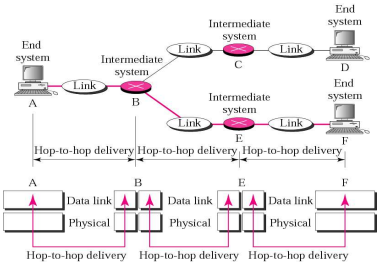
Data Link Layer

- **Flow control** prevents a fast sender from overwhelming a slower receiver.
  - ✓ For example, a supercomputer can easily generate data faster than a PC can consume it.



Layer-2: Data Link layer

Hop-to-Hop delivery



Network Layer

Specific Responsibilities of Network Layer

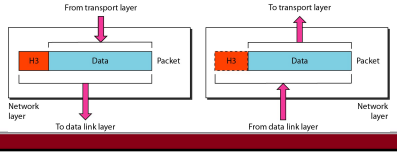
- **Logical addressing**
  - ✓ Data Link layer handles addressing problem locally
  - ✓ If a packet passes the network boundary, we need another addressing system to help distinguish the Source and Destination systems
- **Routing**
  - ✓ required for a packet to travel from network to network
  - ✓ Performing by the connecting devices (routers or gateways)

Network Layer

- The network layer is responsible for the delivery of individual packets from the source host to the destination host.
- The basic purpose of the network layer is to provide an end-to-end communication
  - ✓ Data Link layer provides the machine-to-machine communication

Network Layer

- The network layer logically concatenates a set of links to provide
  - ✓ the abstraction of an end-to-end connection (to the transport layer).
- The network layer is handed a piece of data by the transport layer
  - ✓ Delivering the packets to the correct destination.



Network Layer

- The Network Layer is responsible for
  - ✓ Sending the packets, which includes **data plus source and destination addresses**
- The end-to-end connection is performed using two basic approaches
  1. Connection-oriented Network-layer Services.
  2. Connectionless Network-layer Services.

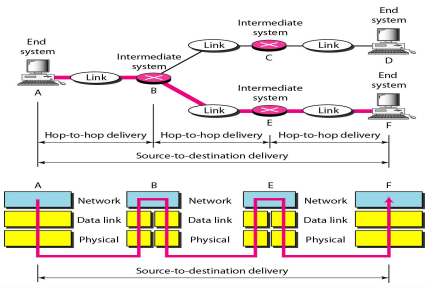
Connection-Oriented Network-layer Services.

- In Connection-Oriented approach is also known as virtual circuit approach,
  - ✓ A route consists of logical connection that establishes first between two users.

Connection-Less Network-layer Services.

- The Connection-Less is also called as datagram approach which is a self-contained message unit.
- This approach contains sufficient information for routing from the source node to the destination node.
- This approach does not dependent on previous message that interchanges between them.

Network Layer: Source-to-Destination Delivery



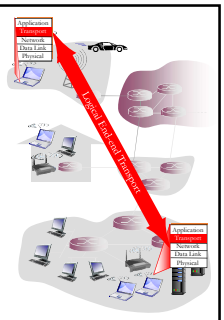
Transport Layer

Specific Responsibilities of Transport Layer

- Service-point addressing (port addresses used in TCP)
- Segmentation and reassembly
- Control connection: connectionless or connection-oriented
- Flow control (end to end, not just a single link)
- Error control (end to end, not just a single link)

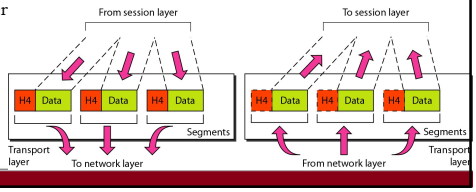
Transport Layer

- Transport Layer provide logical end-to-end communication between application processes running on different hosts
- The Transport Layer is responsible for the delivery of a message from one process to another.



Transport Layer

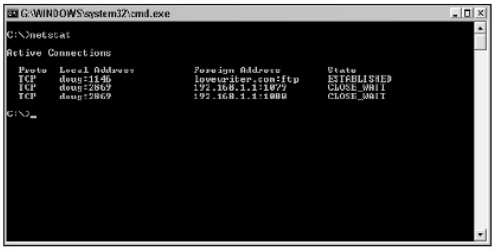
- Transport protocols run in end systems
  - ✓ **Sender side:** breaks application messages into segments, passes to network layer
  - ✓ **Receiver side:** reassembles segments into messages, passes to application layer



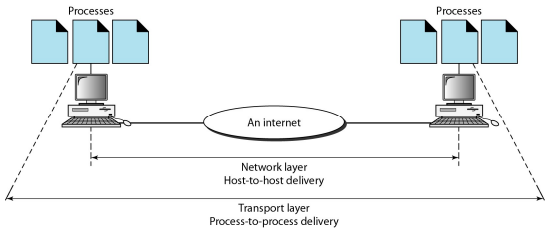
Transport Protocols

- Two Popular transport protocol available one is **TCP** and other is **UDP**
  - ✓ **Transport Control Protocol (TCP)** is a connection-oriented protocol which provides error recovery, flow control, and congestion control.
  - ✓ **User Datagram Protocol (UDP)** does not provide any of these services.

Transport Protocols



Reliable Process-to-Process Delivery of a Message



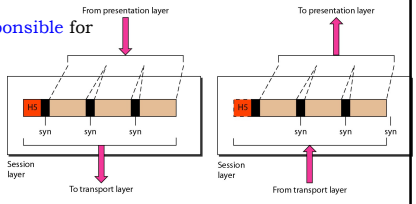
Session Layer

Specific Responsibilities

- **Dialog control :** Allows two systems to enter into a dialog communication between two processes:
  - ✓ half-duplex or full-duplex
- **Synchronization:** add check points into a stream of data

Session Layer

- The Session layer allows users on different machines to establish session between them.
- The session layer is responsible for
  - ✓ **Dialog Control**
  - ✓ **Token Management**
  - ✓ **Synchronization.**



Synchronization.

- Session layer provides checkpoints into data streams,
  - ✓ if any crash, only the data transferred after the last checkpoint have to be repeated.

Session Layer

- The session layer allows three types of transmission modes:
  - **Simplex:** In this mode, data flows in only one direction.
  - **Half-duplex:** In this mode, data flows in both directions, but only in one direction at a time.
  - **Full-duplex:** In this mode, data flows in both directions at the same time.

Presentation Layer

Presentation Layer: Summary

- The presentation layer is responsible for
  - ✓ **Translation,**
  - ✓ **Compression,**
  - ✓ **Encryption**

Presentation Layer

- This layer was intended to provide the mechanism
  - ✓ to convert of the data being transmitted to the appropriate format depending on the machine architecture.
- This layer is concerned with Syntax and Semantics of the information transmitted

Presentation Layer

- The Presentation layer also apply sophisticated **compression techniques**
  - ✓ Using fewer bytes of data are required to represent the information when it's sent over the network.
  - ✓ At the other end of the transmission, the Presentation layer then uncompresses the data.

Presentation Layer

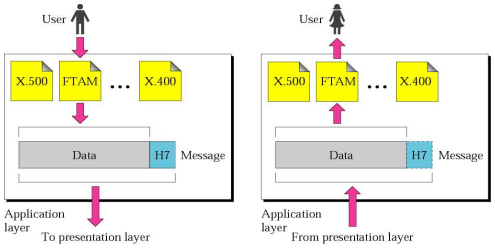
- The Presentation layer also support **sophisticated encryption technique**
  - ✓ Scramble the data before it is transmitted and unscramble it at the other end

Application Layer

Application Layer:

- The application layer consists of the set of applications running on the end hosts.
  - ✓ Examples are the **World Wide Web (the HTTP protocol), Email, Telnet, FTP, and Streaming.**
- The application layer is responsible for providing services to the user.

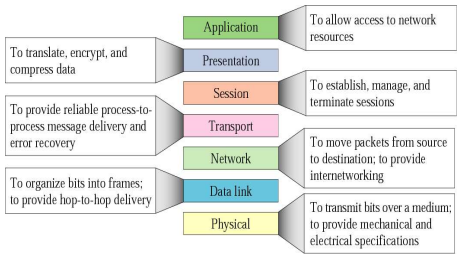
Application Layer:



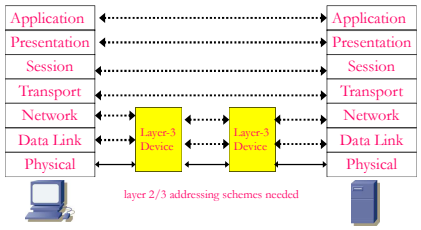
Application Layer:

- Some of the better-known **Application layer protocols** are
  - **DNS (Domain Name System)** for resolving Internet domain names.
  - **FTP (File Transfer Protocol)** for file transfers.
  - **SMTP (Simple Mail Transfer Protocol)** for e-mail.
  - **SMB (Server Message Block)** for file sharing in Windows networks.
  - **NFS (Network File System)** for file sharing in UNIX networks.
  - **Telnet** for terminal emulation.

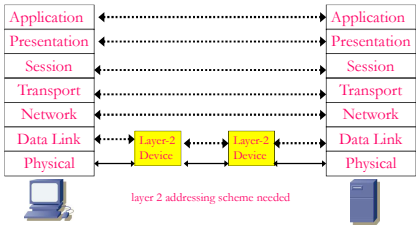
Summary



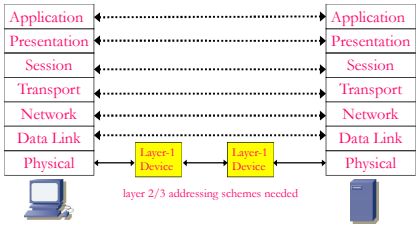
Connection via LAYERS-3



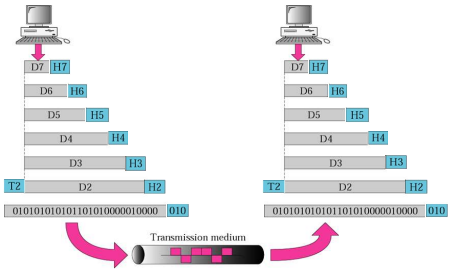
Connection via LAYERS-2



Connection via LAYERS-1



An Exchange using the OSI model



Limitation :OSI model "It's just a model"

7	Application
6	Presentation
5	Session
4	Transport
3	Network
2	Data Link
1	Physical

TCP/IP Reference Model

TCP/IP Reference Model

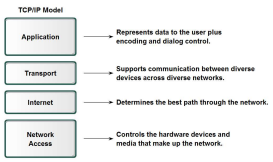
- The TCP/IP Model are also called as Internet Protocol Suite
  - ✓ Describes a set of general design guidelines and implementations of specific networking protocols to enable computers to communicate over a network.
- **TCP/IP** provides end-to-end connectivity specifying
  - ✓ how data should be formatted, addressed, transmitted, routed and received at the destination.

TCP/IP Reference Model

- TCP/IP Model is the set of computer network communications protocols and a description framework used for the **Internet** and other similar networks.
- The TCP/IP Model was created in the **1970s by DARPA,** an agency of the United States Department of Defense (DOD).

TCP/IP Layers

- The layers in the TCP/IP protocol suite **do not exactly match** those in the OSI model.
- The original TCP/IP protocol suite was defined as having **four layers**:
  - ✓ **Host-to-network Layer ,**
  - ✓ **Internet Layer,**
  - ✓ **Transport Layer,**
  - ✓ **Application Layer.**



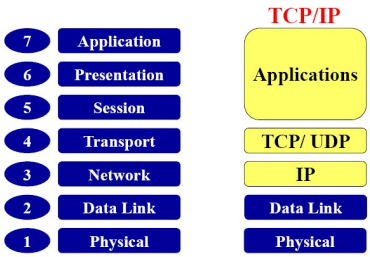
TCP/IP Layers

❖ When TCP/IP is compared to OSI, we can say that the **TCP/IP protocol suite is made of five layers:**

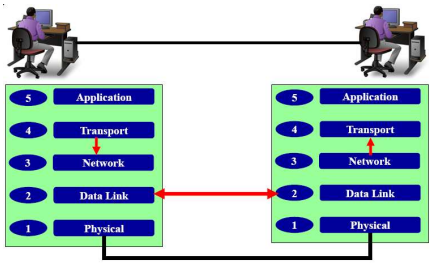
- ✓ **Application Layer.**
- ✓ **Transport Layer**
- ✓ **Network Layer**
- ✓ **Data link Layer**
- ✓ **Physical Layer**

5	Applications	User service and interface
4	Transport	Process delivery + Error (TCP/UDP) Reliable end-to-end (whole message)
3	Network	Move packets from source to destination Packet end-to-end (across network)
2	Data Link	Provide frames Node-to-node (same network segment)
1	Physical	Transmission bit streams (mechanical and electrical spec)

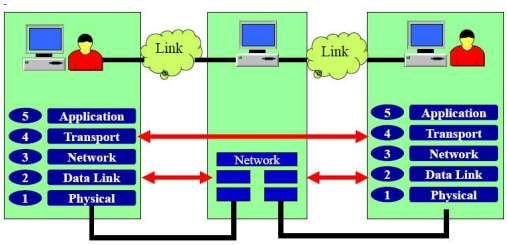
Comparison of OSI TCP/IP Reference Model



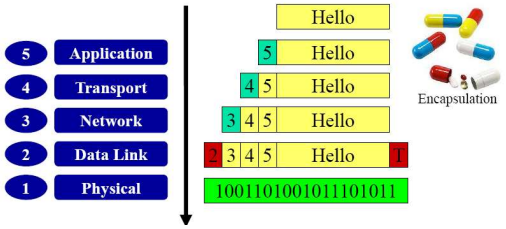
Direct Connection



Connection via Intermediate nodes

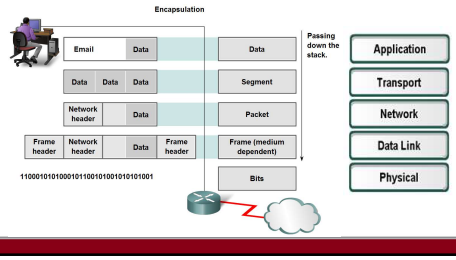


Data Flow in a station

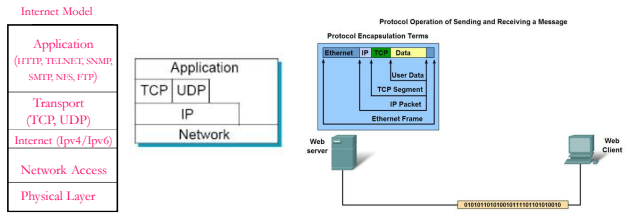


Encapsulation

- Encapsulation is the process of embedding a header or trailer

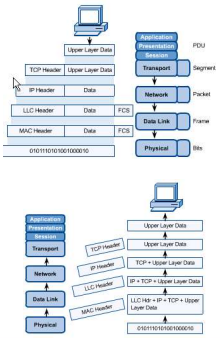


Encapsulation

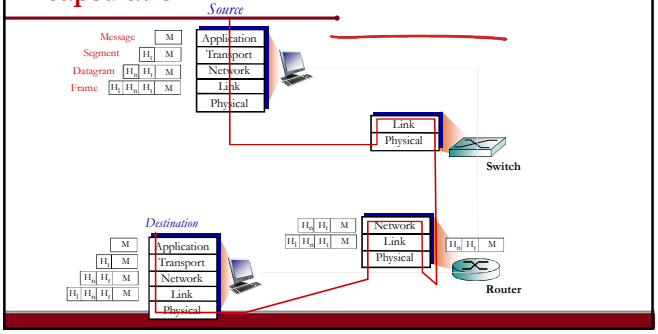


Encapsulation

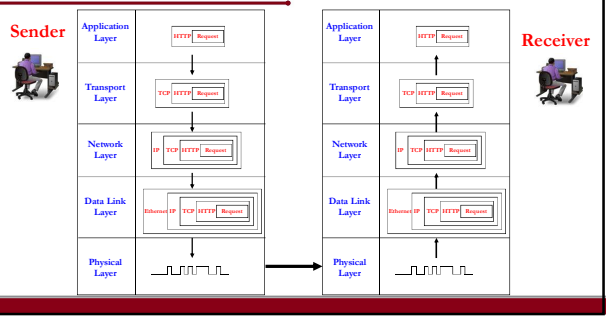
- As the message moves to the lower layer, each successive OSI model layer adds a header to it.
- A **header** is layer-specific information that basically explains what functions the layer carried out.
- Conversely, at the receiving end, headers are striped from the message as it travels up the corresponding layers.



Encapsulation

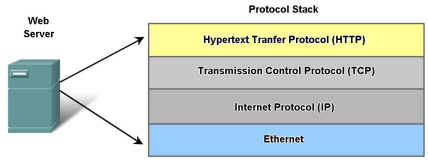


Encapsulation

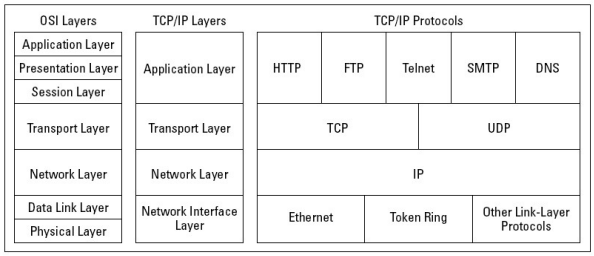


Internet Protocol Stack

- A list of protocols used by a certain system, one protocol per layer, is called **a protocol stack.**



TCP/IP and the OSI



Concept : OSI and TCP/IP

Concept : OSI and TCP/IP

- Open System Interconnection(OSI) was developed by ISO as a first step toward international standardization of the protocol used in various layers.
- It deals with connecting open system..
- Transport Control Protocol /Internet Protocol (TCP/IP):
  - ✓ TCP is used in connection with IP and operates at the transport layer.
  - ✓ **IP** is the set of convention used to pass packets from one host to another.

Similarities OSI and TCP/IP

- Both the Models are based on the concept of a stack of independent protocols.
- The functionality of the layers is roughly similar.
  - ✓ They share similar architecture. i.e Both of them are constructed with layers.
  - ✓ They share a common application layer. Both of the models share a common "application layer". However, Differs in services depending upon application

Comparison OSI and TCP/IP

OSI	TCP/IP
❖ OSI makes the distinction between Services, Interfaces, and Protocol.	❖ TCP/IP does not originally clearly distinguish between services, interface, and protocol.
❖ The OSI model was devised before the protocols were invented. It can be made to work in diverse heterogeneous networks.	❖ TCP/IP model was just a description of the existing protocols. The **model and the protocol fit perfectly.**

OSI	TCP/IP
❖ The OSI model supports both connectionless and connection-oriented communication in the **network layer,** ✓ Only connection-oriented communication in the **transport layer.**	❖ TCP/IP model has only connectionless mode in the **network layer** ✓ Supports both connectionless and conn-oriented comm.. modes in the **transport layer**, giving the user choice.

OSI

- OSI emphasis on providing a **reliable data transfer service,**
  - ✓ Each layer of the OSI model detects and handles errors, all data transmitted includes checksums.
  - ✓ The transport layer checks source-destination reliability.

TCP/IP

- TCP/IP treats reliability as an end to end Problem.
  - ✓ The transport layer handles all error detection and recovery,
  - ✓ it was checksums, timeouts and acknowledgments to control transmissions and provides end-to-end verification.

OSI

- OSI has seven layers
- Host on OSI implementations do not handle network operations.

TCP/IP

- TCP/IP has four layers
- TCP/IP hosts participate in most network protocols.

Goals:

- **Networks Software Model**
- **Layering Concept**
  - ✓ **Open System Interconnection**
    - **Specific Responsibilities of each layer**
  - ✓ **TCP/IP Reference Model**
- **Comparison OSI and TCP/IP**
- **Analyzing the TCP/IP Using Wireshark (Active Learning)**