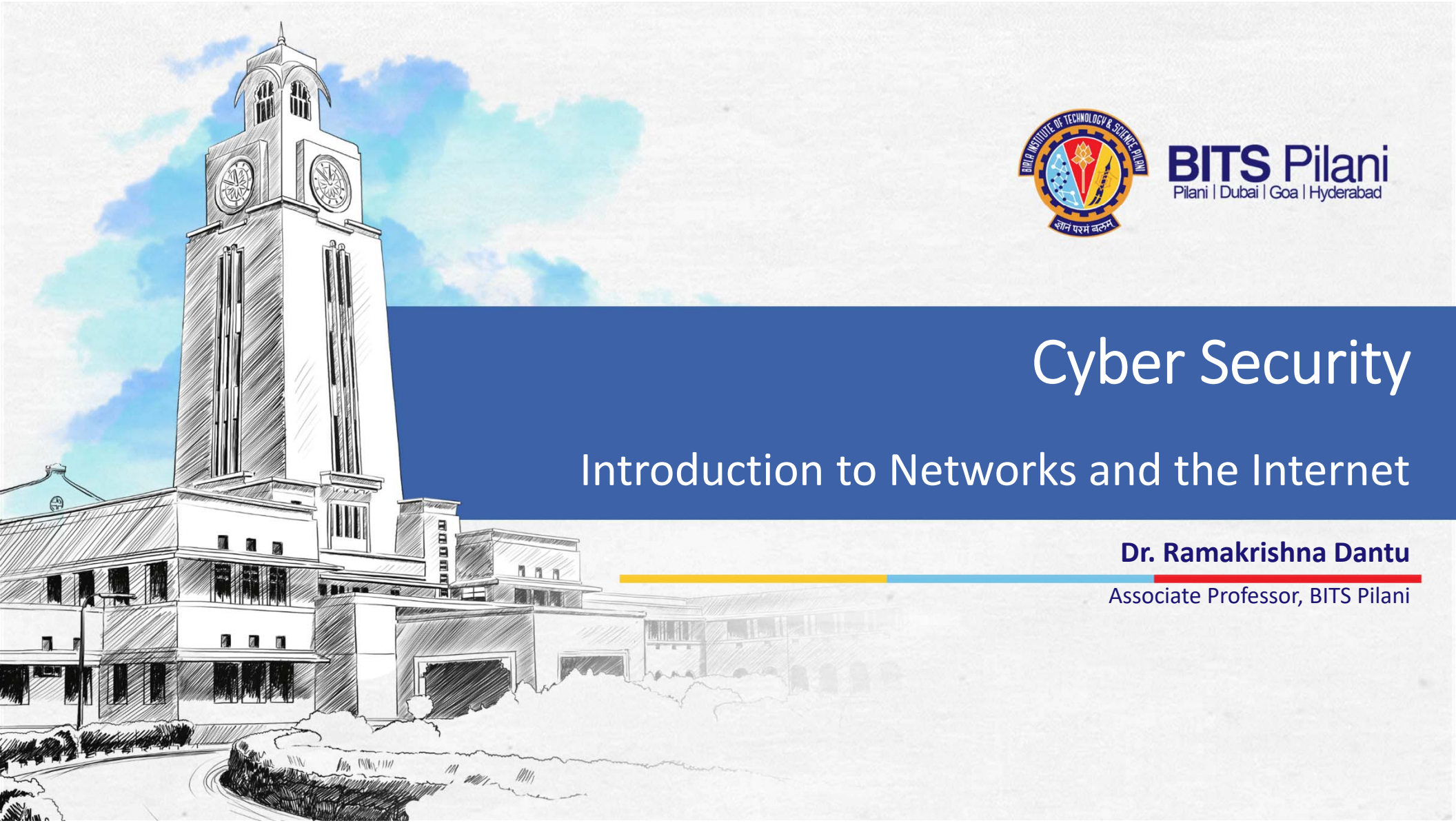

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Cyber Security

Introduction to Networks and the Internet

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Disclaimer and Acknowledgement

- The content for these slides has been obtained from books and various other source on the Internet
- I here by acknowledge all the contributors for their material and inputs.
- I have provided source information wherever necessary
- I have added and modified the content to suit the requirements of the course

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The OSI Model

The OSI Model

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Overview

- Open Systems Interconnection (OSI) model describes how computers communicate with each other on a network
- It outlines the various protocols and activities, and tells how the protocols and activities relate to each other

The OSI Model

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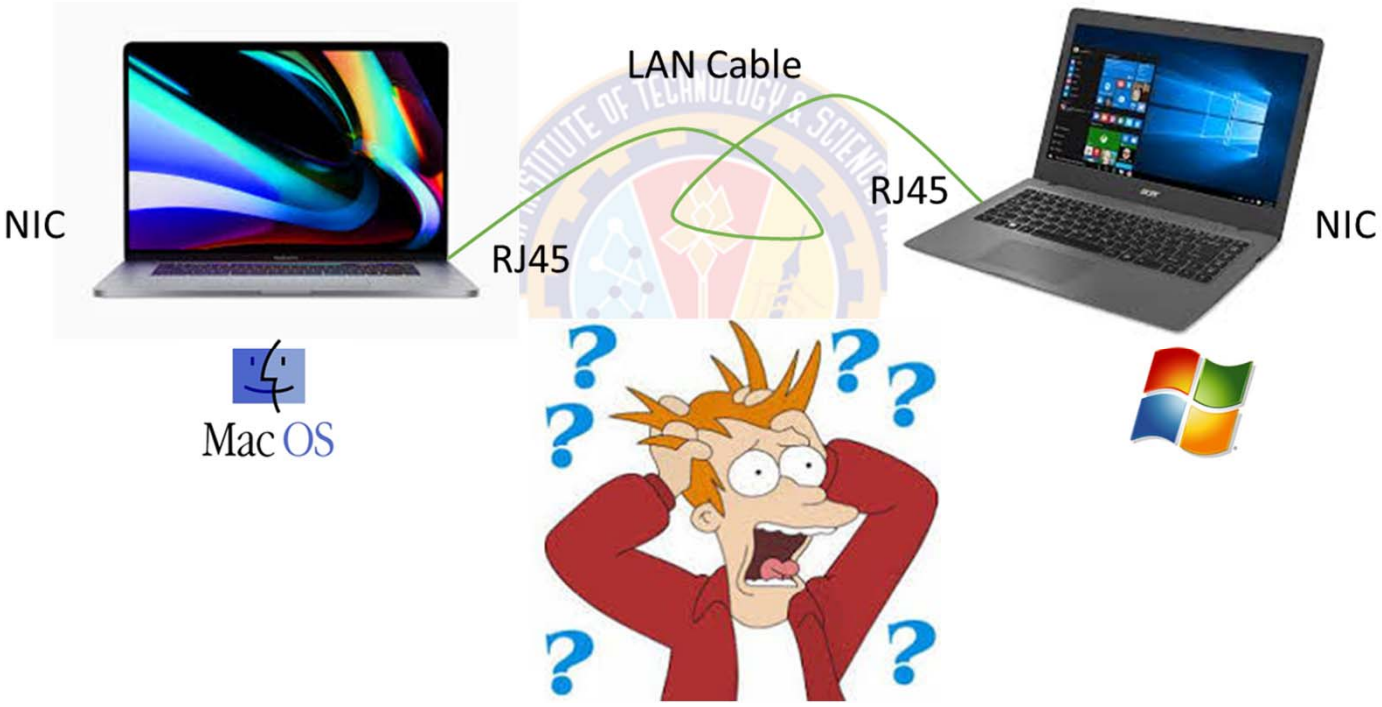
Overview



The OSI Model

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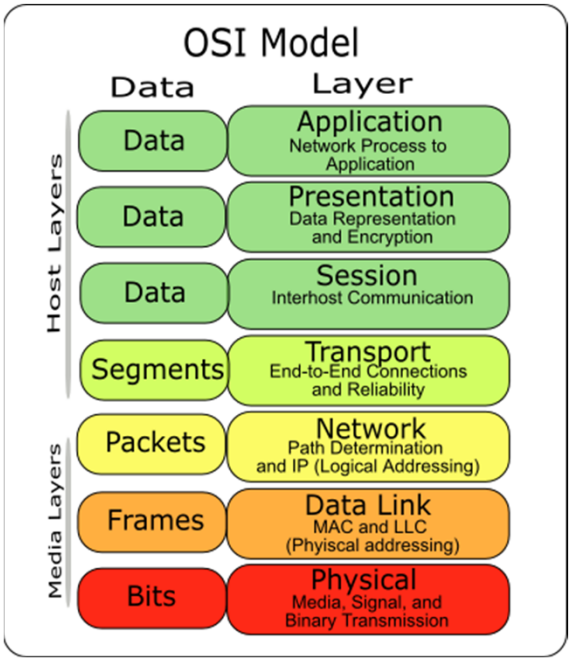
Overview

- This model was originally developed by the International Organization for Standardization in 1984
- The model is divided into seven distinct and separate layers
- Each layer is a package of protocols
- Each layer possesses a trait known as 'successive dependence'
  - This means that the successively higher layers in the model depend on the services and characteristics of the preceding lower layers

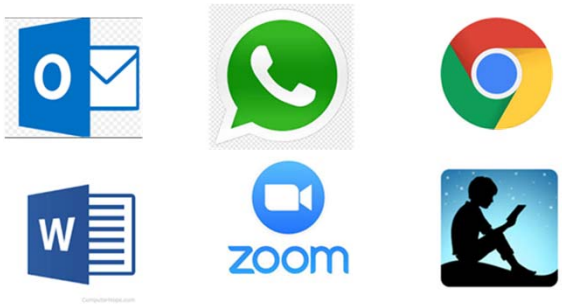


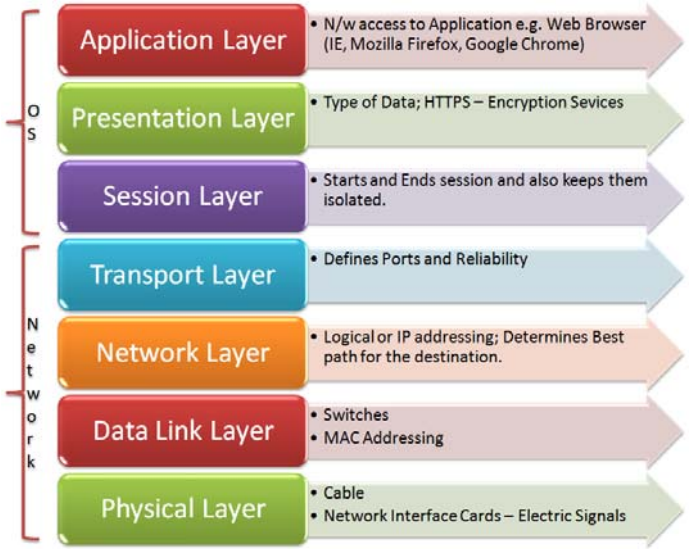
Open Systems Interconnection (OSI) Model

The OSI Model

Layer 7: Application Layer

- This doesn't mean applications such as chrome, email client, word processor, etc.,.
- The application layer is the end user's access to the network
- This layer includes protocols to make these applications work correctly
- These are applications that rely on the Internet to work
- For Example:
  - Chrome, Skype, Outlook, etc.,.

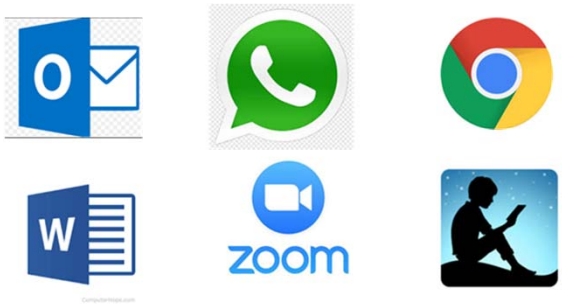


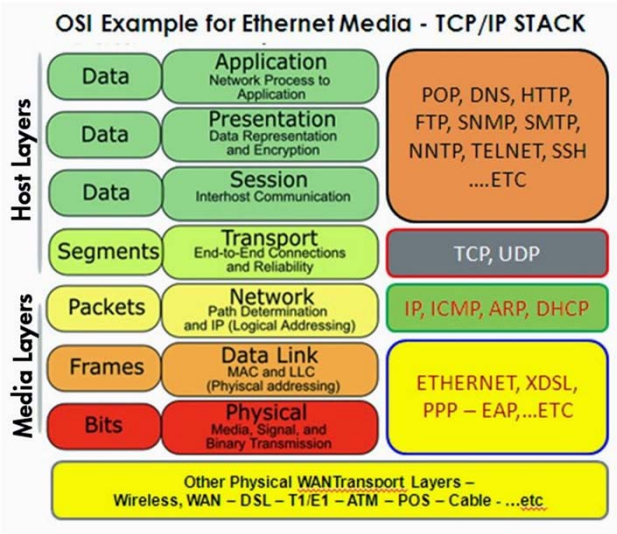


The OSI Model

Layer 7: Application Layer

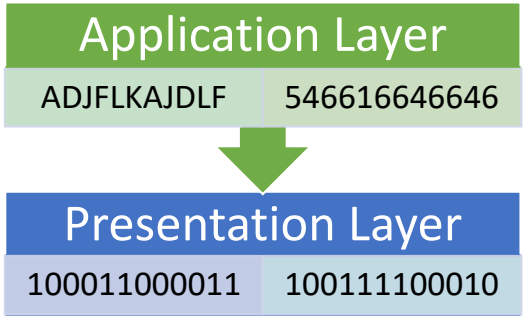
- The Application Layer protocols form the basis for various network services such as
  - File transfer, Web surfing, Emails, Virtual terminals, etc.,.
- For example:
  - File transfer relies on FTP
  - Web surfing relies on HTTP/HTTPS
  - Emails use SMTP
  - Virtual terminals use Telnet





The OSI Model

Layer 6: Presentation Layer

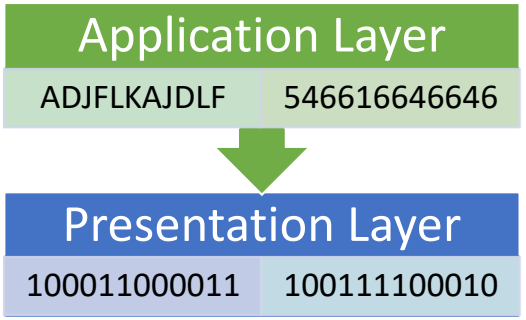


- This layer receives data in the form of characters and numbers from the Application Layer
- The presentation layer performs two functions: Translation and Compression
- Translation
  - The presentation layer converts this data into machine understandable binary format (0's and 1's)
    - E.g., conversion of ASCII to EBCDIC
      - Extended Binary Coded Decimal Interchange Code
- Compression
  - Before the data is transmitted, the presentation layer reduces the number of bits used to represent the original data
    - 100011000011 → 10010011
  - Data compression can be lossy or lossless

The OSI Model

Layer 6: Presentation Layer

- Data compression reduces the amount of space required to store the original file
  - E.g., 5MB → 3MB
- As the file size is reduced, data transmission can happen faster
- Data compression is useful in real-time audio and video streaming
- Data is encrypted before transmission to maintain the integrity/security of the data
- At the receiver side, data is decrypted, before presenting
- Secure Socket Layer (SSL) protocol is used in the presentation layer for encryption and decryption
- Essentially, presentation layer performs three functions:
  - Translation, Compression, & Encryption/Decryption



The OSI Model

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Layer 5: Session Layer

- Suppose we decide to have a party at our home

- We hire an event management team to help us organize party


setting up


assisting


cleaning

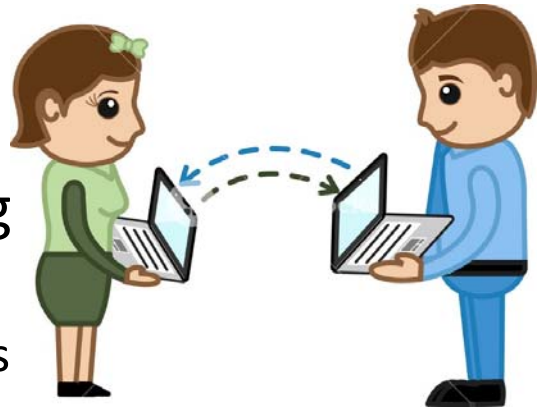
closing the party

- The Session Layer performs a similar function

The OSI Model

Layer 5: Session Layer

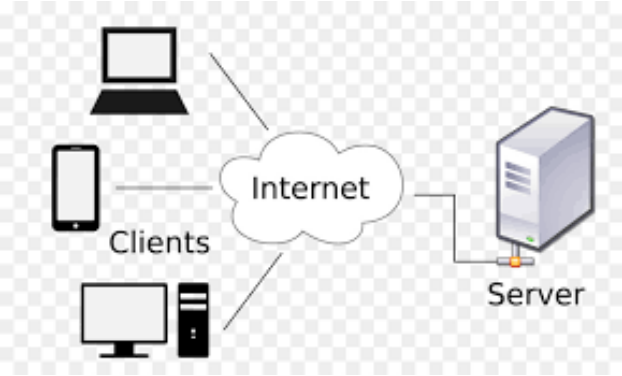
- The session layer is responsible for setting up and managing all connections or sessions
- It enables sending and receiving of data, followed by the termination of connections or sessions
- Similar to the way we had helpers in organizing the party, session layer also has its own helpers
- These helpers are called Application Programming Interfaces (APIs)
  - E.g., NETBIOS – Network Basic Input/Output System allows different computers to communicate with each other



The OSI Model

Layer 5: Session Layer

- Session Layer performs two functions – Authentication & Authorization
- Authentication
  - Before establishing a session or connection, the server performs authentication
  - Authentication process verifies the identity of the client where the user name and password are matched
  - Once authenticated, a session or connection is established between the computer and the server
- Authorization
  - Once authenticated the user, authorization is checked
  - Authorization is the process where the server checks if the user has permission to access a file or any resource
  - If not, users gets a message saying "Access Denied"



The OSI Model

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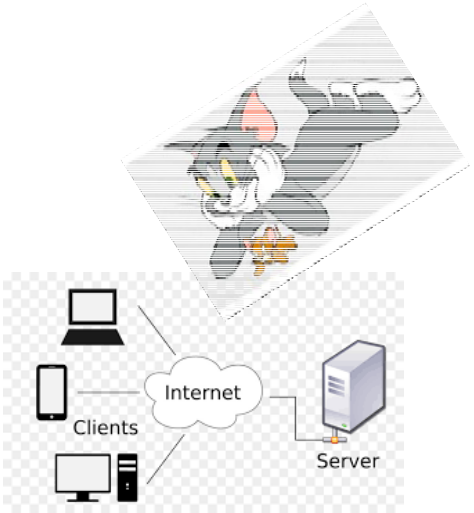
Layer 5: Session Layer

- Session layer also performs session management
- Session layer keeps track of files that are being downloaded
- For e.g., a web page contains images, text, etc.



- These images and text are stored as separate files on the web server

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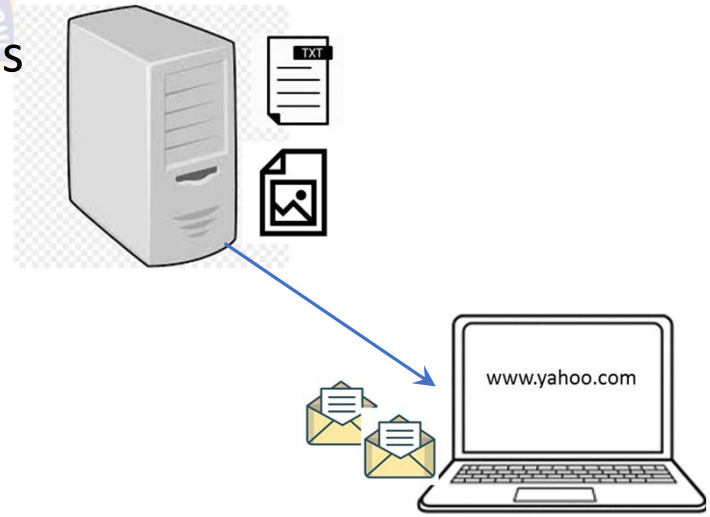
Layer 5: Session Layer

- When we request a web page, web browser opens a separate connection or session with the server
- This session enables us to download each of these text and image files separately
- These files are received in the form of data packets
- Session layer keeps track of which data packet belongs to which file
- It also tracks where the received packet should go (the destination)
  - in this case, it goes to web browser
- Thus session layer helps in session management



The OSI Model

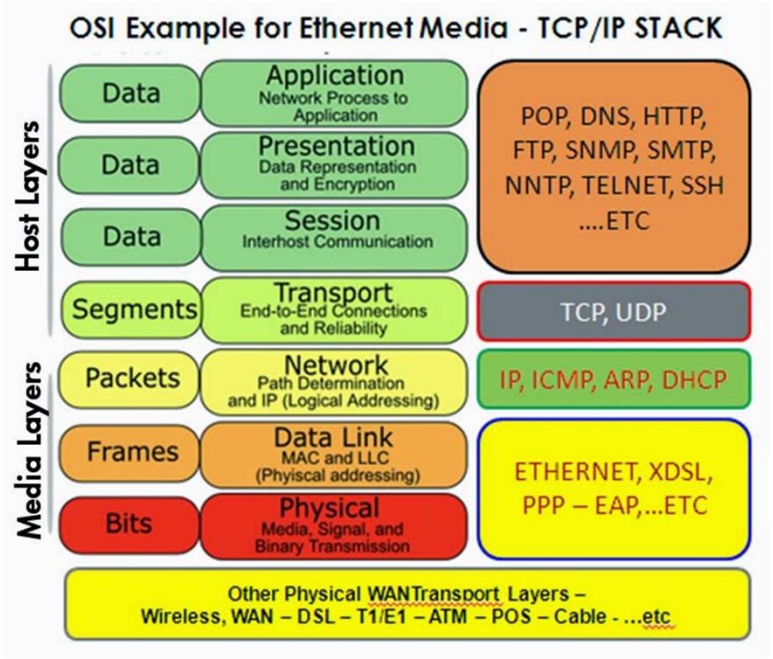
Layer 5: Session Layer

- Thus, the session layer performs three key functions
  - Authentication
  - Authorization
  - Session Management
- Our web browser performs all these functions of:
  - Session layer
  - Presentation layer, and
  - Application layer

The OSI Model

Layer 4: Transport Layer

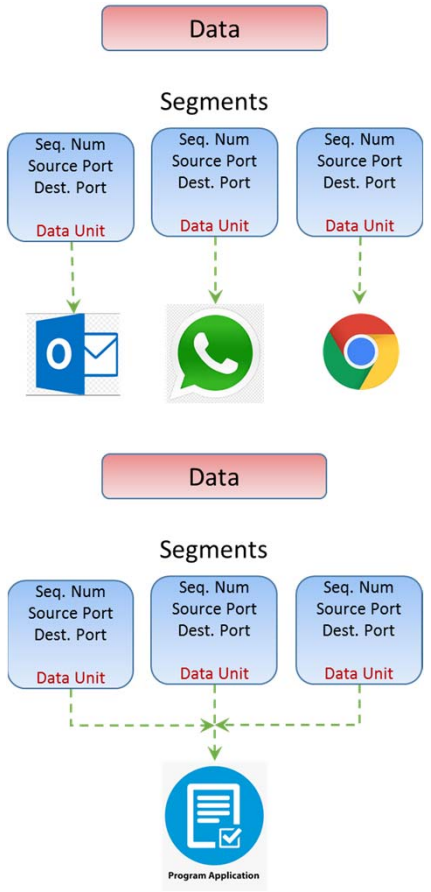
- The transport layer deals with end-to-end issues, such as procedures for entering and departing from the network
- Transport layer controls the reliability of communication through
  - Segmentation
  - Flow Control
  - Error Control
- It is responsible for:
  - breaking a large data into smaller packets (if needed),
  - ensuring that all the packets have been received,
  - eliminating duplicate packets, and
  - performing flow control to ensure that no computer is overwhelmed by the number of messages it receives



The OSI Model

Layer 4: Transport Layer

- Segmentation
  - Data is divided into smaller units called segments
  - Each segment contains:
    - port number of source and destination, and
    - sequence number
  - Port number helps direct each segment to the correct application
  - Sequence number helps to reassemble the segments in correct order to form correct message at the receiver
    - so that it can be delivered to the correct application in that order



The OSI Model

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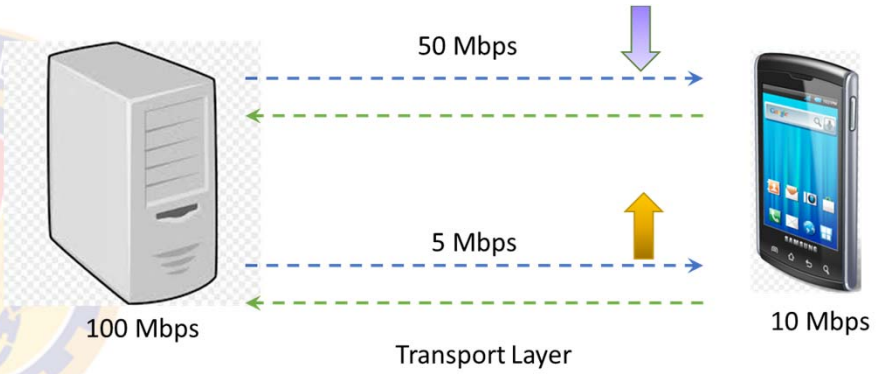
Layer 4: Transport Layer

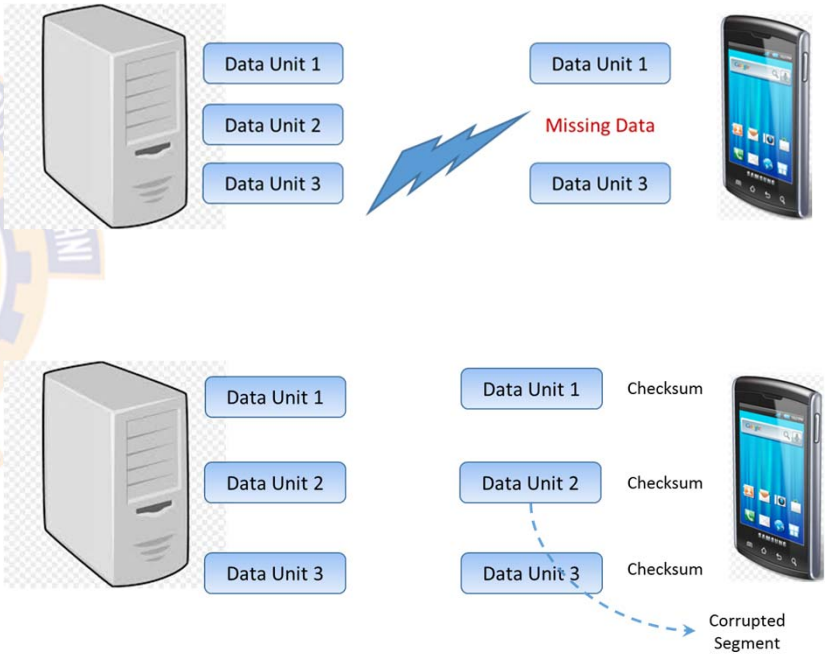
- Flow Control
  - Here, transport layer controls the amount of data being transmitted
  - Consider that the
    - server can transmit data at a maximum of 100 Mbps
    - mobile phone can process data at a maximum of 10 Mbps
  - Server sends data at 50 Mbps
    - This is more than the processing capacity of mobile phone
    - Mobile phone with the help of transport layer can tell the server to slow down data transmission rate to 10 Mbps so there is no data loss
  - Server sends data at 5 Mbps
    - Mobile phone tells the server to increase the speed to 10 Mbps to maintain system performance



The OSI Model

Layer 4: Transport Layer

- Error control
  - Transport layer also performs error control
  - If a data packet doesn't arrive at the destination, transport layer uses Automatic Repeat Request scheme to retransmit the lost or corrupted data
  - A group of bits called checksum is added to each segment by the transport layer to find out received corrupted segment



The OSI Model

Layer 4: Transport Layer

- Transport layer protocols are
  - Transmission Control Protocol (TCP)
  - User Datagram Protocol (UDP)
- Transport layer performs two types of transmission services
  - Connection-oriented Transmission
    - Done using TCP
  - Connectionless Transmission
    - Done using UDP

The OSI Model

Layer 4: Transport Layer

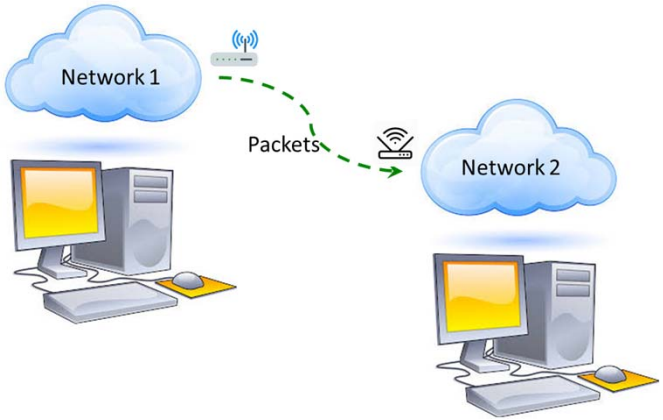
- UDP Vs. TCP
  - UDP is faster than TCP, because
    - UDP does not provide any feedback
    - TCP provides feedback so that lost data can be retransmitted
  - UDP is used where it doesn't matter if we received all data
    - E.g., Online video streaming, Songs, Games, VOIP
  - TCP is used where full data delivery is must
    - E.g., WWW, Email, FTP, etc.,

TCP	UDP
Connected	Connectionless
State Memory	Stateless
Byte Stream	Packet/Datagram
Ordered Data Delivery	No Sequence Guarantee
Reliable	Lossy
Error Free	Error Packets Discarded
Handshake	No Handshake
Flow Control	No Flow Control
Relatively Slow	Relatively Fast
Point to Point	Supports Multicast
Security: SSL/TLS	Security: DTLS

The OSI Model

Layer 3: Network Layer

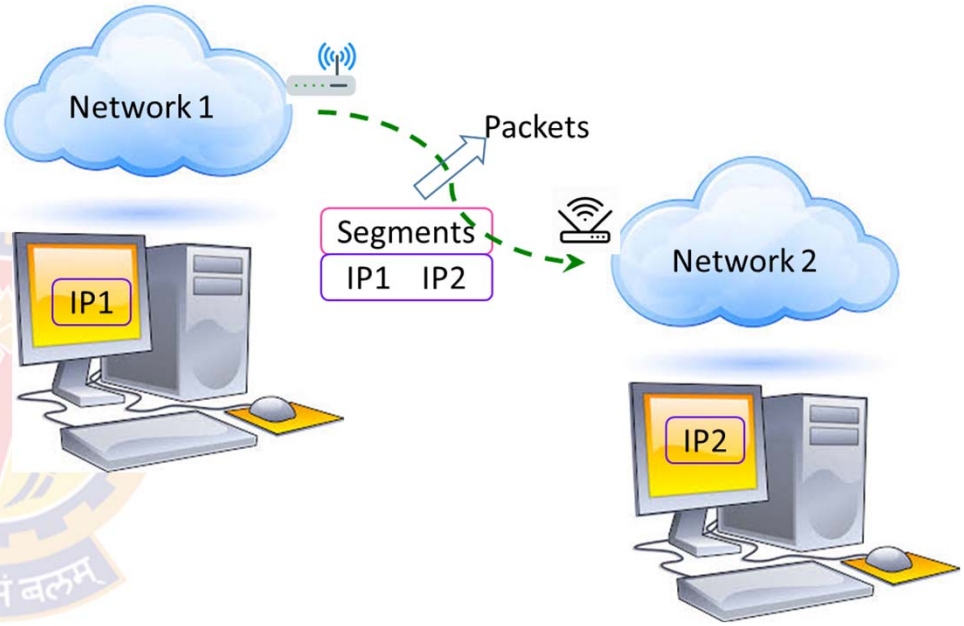
- Transport layer passes data segments to Network Layer
- Network layer works for the transmission of received data segments from one computer to another located in different networks
- Data units in the network layer are called packets
- It is the layer where routers reside
- Key functions of network layer are
  - Logical addressing
  - Routing
  - Path determination



The OSI Model

Layer 3: Network Layer

- Logical addressing
  - IP addressing (IPv4 & IPv6) done in network layer is called Logical Addressing
  - Every device in a network has a unique IP address
  - Network layer assigns sender's and receiver's IP address to each segment to form an IP packet
  - IP addresses are assigned to ensure that each data packet reaches the correct destination



The OSI Model

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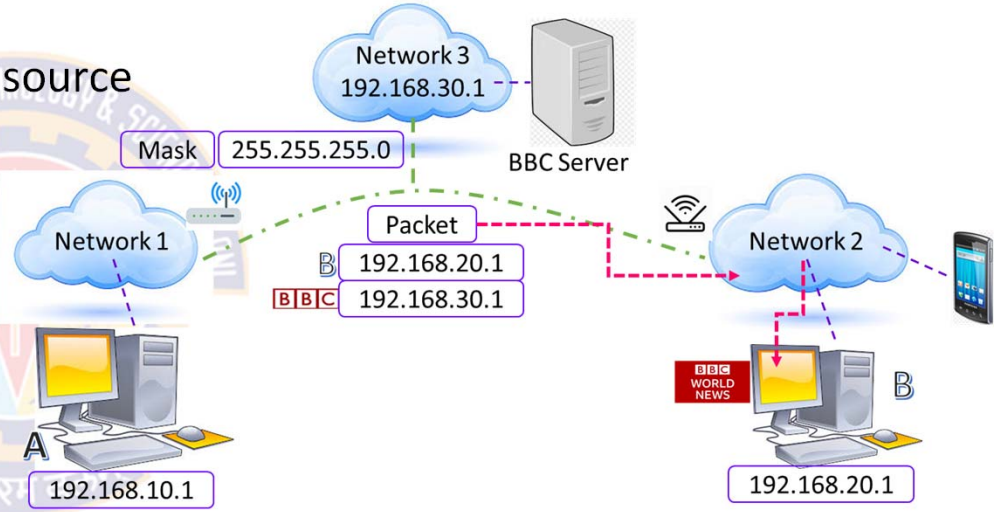
Layer 3: Network Layer

- Routing
  - Routing involves moving data packets from source to destination
  - Based on IP address and mask, routing decisions are made in a computer network
  - Suppose computers A & B are connected to networks 1 & 2 respectively
  - From computer B we requested to access BBC NEWS website
  - There is a reply from BBC server to computer B in the form of a packet
  - This packet must be delivered to computer B only



The OSI Model

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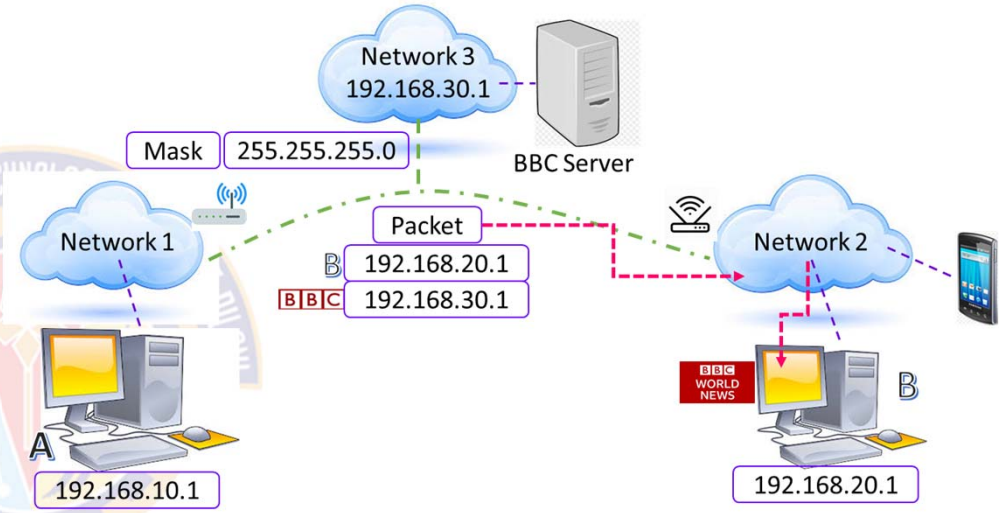
Layer 3: Network Layer

- Routing
  - Both computers A & B have their unique IP addresses
  - Network layer of the BBC server adds sender and receiver's IP address in the packet
  - The mask 255.255.255.0 tells that the first three octets (192.168.20.1) of the IP address represent network, while the last octet represents host or computer B
  - Based on the IP address format, the data packet will first move to network 2 and then to computer B
  - Based on IP address and mask, routing decisions are made in a computer network



The OSI Model

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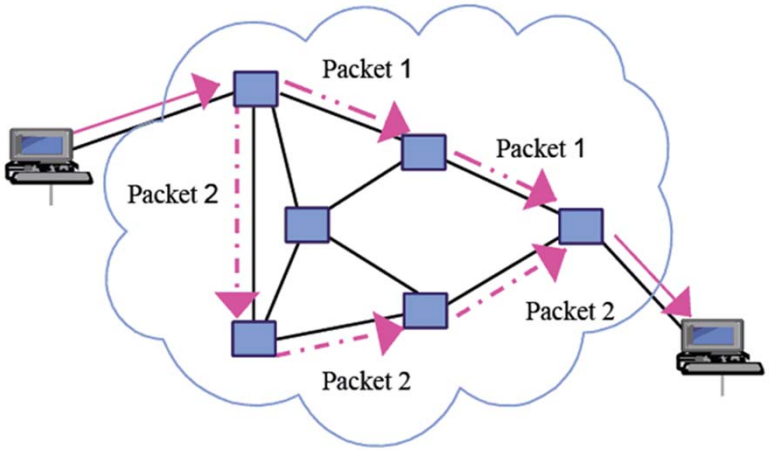
Layer 3: Network Layer

- Path Determination
  - A computer can be connected to an Internet server in a number of ways
  - Choosing the best possible path for data delivery from source to destination is called path determination
  - Layer 3 devices use protocols such as:
    - OSPF – Open Shortest Path First
    - BGP – Border Gateway Protocol
    - IS-IS – Intermediate System to Intermediate System

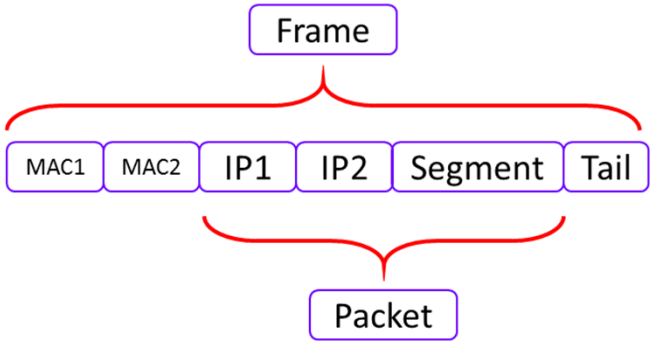
  To determine the best possible path for data delivery

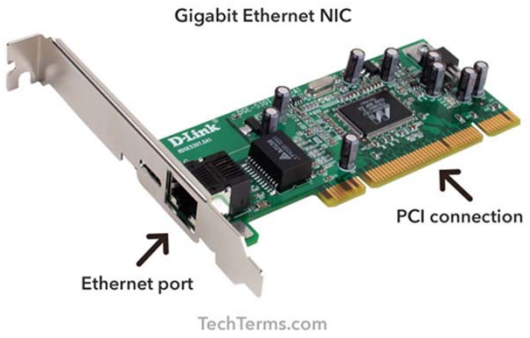


The OSI Model

Layer 2: Data Link Layer

- Data Link Layer receives data packets from the Network Layer
- Data unit in the data link layer is called a frame
- Data packets contain IP addresses of the sender and the receiver
- There are two kinds of addressing: Logical and Physical
- Logical addressing
  - Done in the network layer where sender's and receiver's IP address are assigned to each segment to form a data packet
- Physical addressing
  - Done in the data link layer, where MAC address of sender and receiver are assigned to each data packet to form a frame
  - MAC address is a 12 digit alpha-numeric number embedded in the NIC of a computer





The OSI Model

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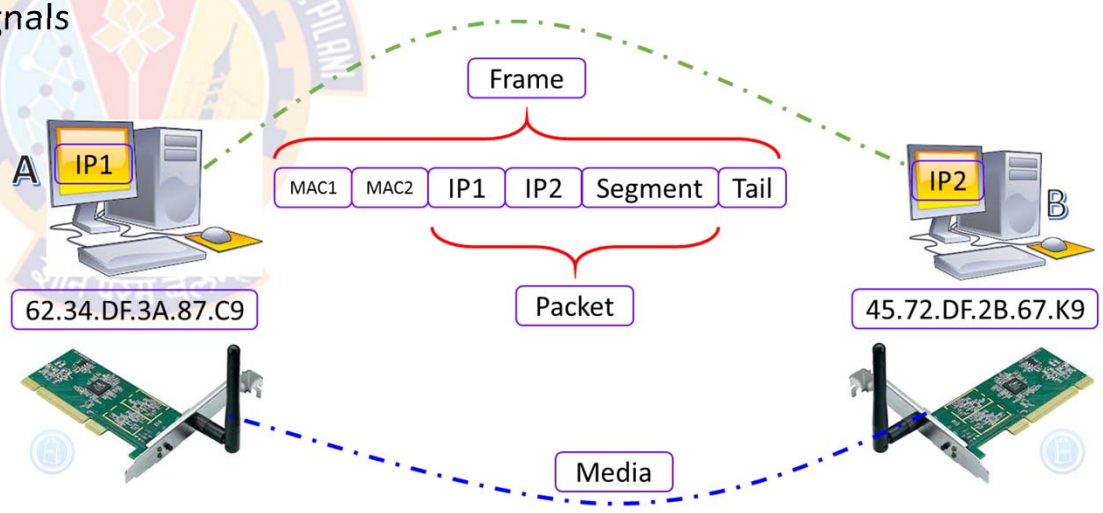
Layer 2: Data Link Layer

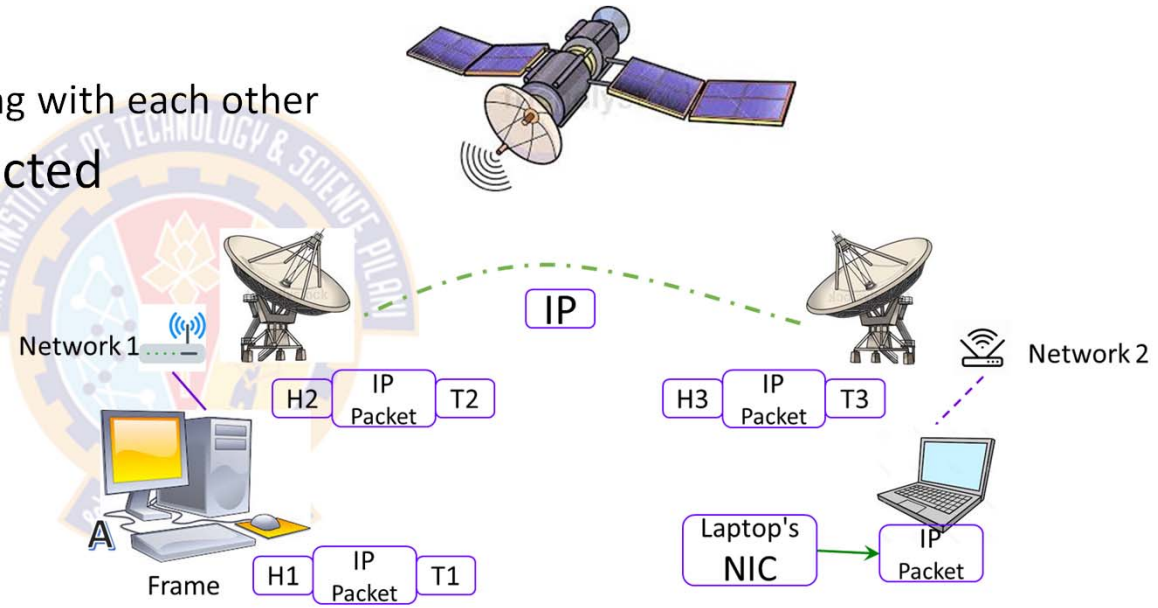
- Data Link Layer is embedded as software in the NIC of the computer
- It provides a means for transferring data from one computer to another via a local media
- Local media includes:
  - copper wire, fiber optics, or air for radio signals
- Data Link Layer performs two basic functions:
  - it allows the upper layers of OSI model to access media
  - controls how data is placed and received from the media using such as
    - Media Access Control (MAC)
    - Error Detection



The OSI Model

Layer 2: Data Link Layer

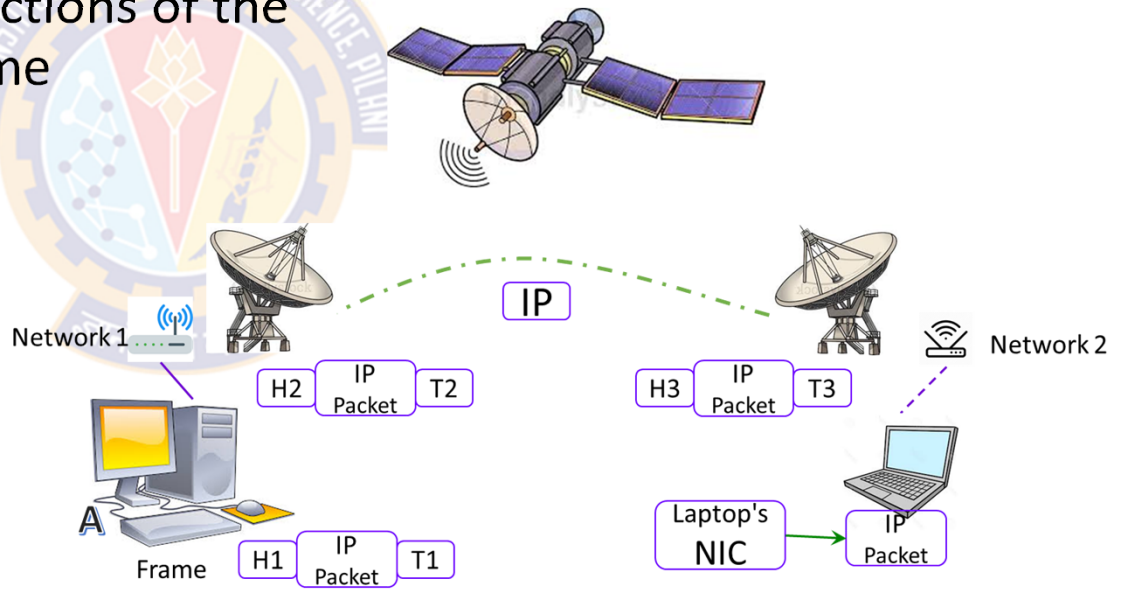
- Consider two distant hosts:
  - A desktop and a Laptop communicating with each other
- As laptop and desktop are connected to two different networks
  - they will be using network layer protocols (E.g., IP) to communicate with each other
- Desktop is connected to router R1 via an Ethernet cable
- Laptop is connected to router R2 via a wireless link
- Router R1 and R2 are connected via a satellite link



The OSI Model

Layer 2: Data Link Layer

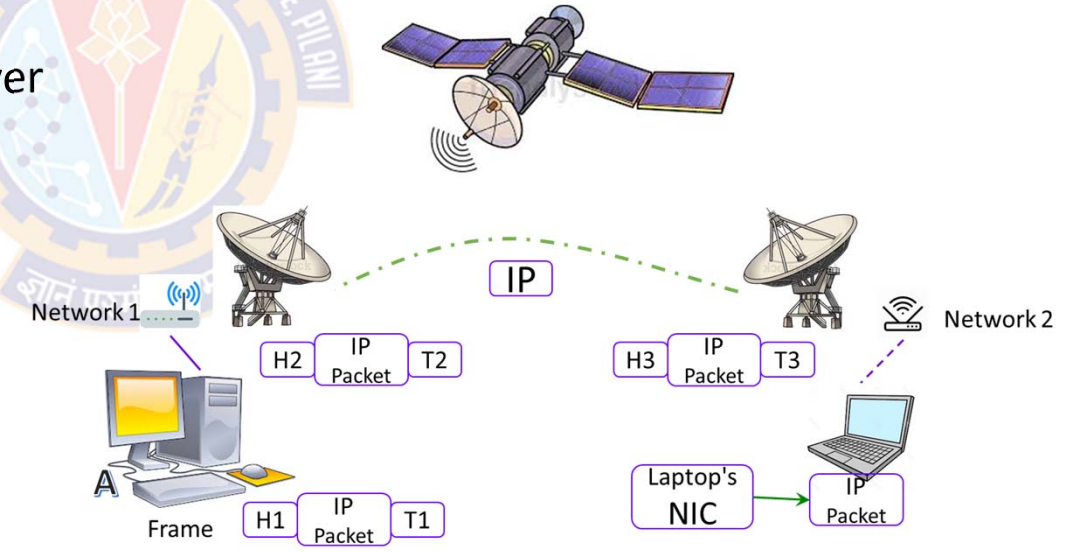
- Desktop tries to send some data to laptop
- Based on the medium used to connect desktop to router R1, data link layer adds some data in the head and tail sections of the IP packet and converts it to a frame (E.g., Ethernet frame)
- Router R1 receives this frame, decapsulates it to an IP Packet and then encapsulates it again to a frame so that it can cross the satellite link to reach router R2



The OSI Model

Layer 2: Data Link Layer

- Router R2 again decapsulates the received frame and encapsulates it again to form a wireless data link frame
- Laptop receives this wireless data link frame, decapsulates it, and forwards IP packet to network layer
- Finally data arrives at the application layer
- Application layer protocols make the received data visible on computer screen
- Higher level layers are able to transfer data over the media with the help of data link layer



The OSI Model

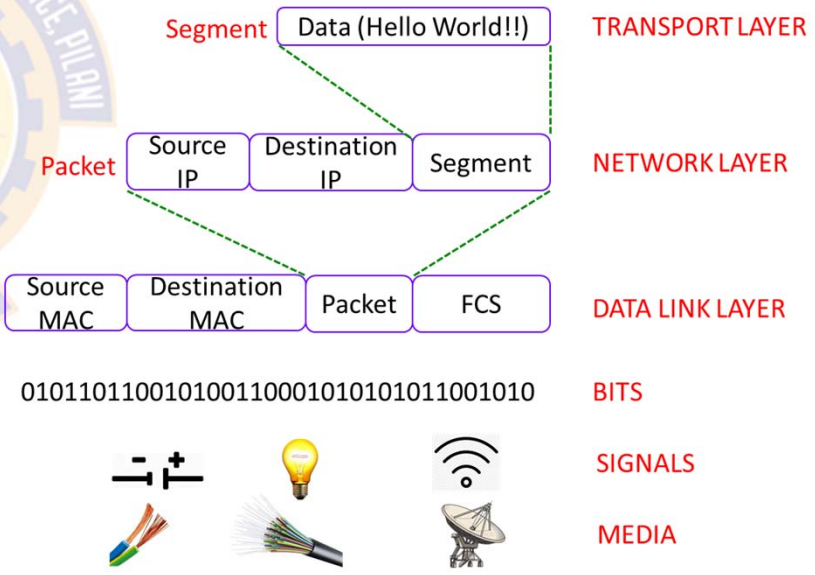
Layer 2: Data Link Layer

- Media Access Control
  - Data link layer also controls how the data is placed and received from the media
  - The technique used to get the frame on and off the media is called Media Access Control
  - There may be a number of devices connected to a common media
  - If two or more devices connected to same media send data simultaneously, there may be collisions of data packets resulting in loss of data
  - To avoid this situation, data link layer keeps an eye on when the shared media is free so that devices can transmit data for the receiver
  - This is called Carrier Sense Multiple Access (CSMA)
- Error Control
  - Tail of each frame contains bits which are used to check for errors in the received frame
  - Errors occur due to certain limitations of the media used for transmitting data

The OSI Model

Layer 1: Physical Layer

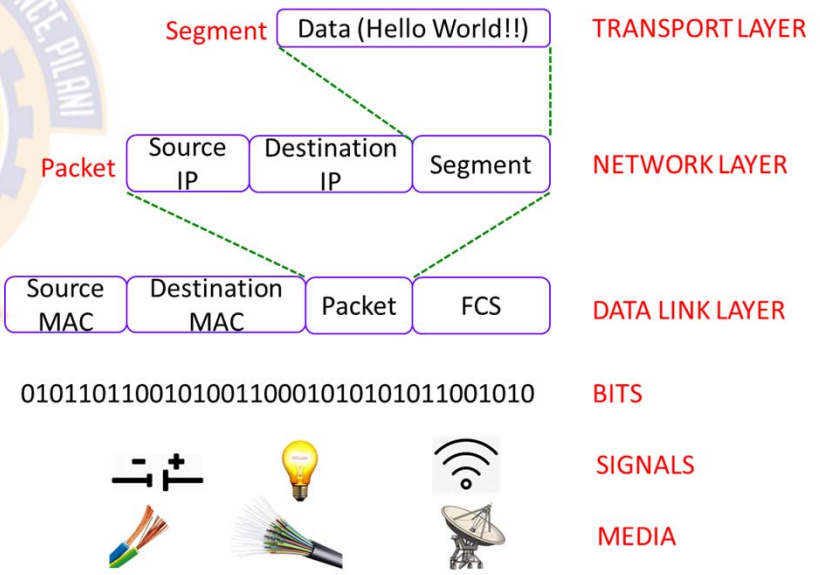
- Till now, data from application layer has been
  - segmented by transport layer,
  - placed into packets by network layer, and
  - framed by data link layer
- This is a sequence of binary 0's and 1's
- Frame check sequence (FCS) is an error-detecting code added to a frame in a communication protocol



The OSI Model

Layer 1: Physical Layer

- Physical layer converts this binary sequence into signals and transmits over the local media
- It can be:
  - an electrical signal (for copper cable),
  - light signal (optical fiber), and
  - radio signal (in case of air)
- Signal generated by physical layer depends on the type of media used to connect two devices



The OSI Model

Seven Layers of the OSI Networking Model

Layer	Description	Protocols
Application Layer	This layer controls and mediates the interaction of the network with the Operating System and the applications installed on this OS It basically defines how the applications handle the communications in which the system becomes involved when connected to a network	POP, SMTP, DNS, FTP, and so on
Presentation Layer	Performs data compression/ decompression and encryption/decryption	
Session Layer	Defines the connection between two computers as either a client-server connection or a peer-to-peer connection The term 'session' is used to describe this virtual network connection between computers	NetBIOS
Transport Layer	Mediates the movement of data between all the other layers	TCP, UDP

The OSI Model

Seven Layers of the OSI Networking Model

Layer	Description	Protocols
Network Layer	Defines the route through which the data packets will travel from node to node For this purpose, the transport layer masks the characteristics of lower layers from the upper layers in the OSI model	IP, Internet Control Message Protocol
Data Link Layer	Bridges the connection between the third layer (network layer) and the first layer (physical layer) by defining and implementing a protocol through which the network layer transmits its data to the physical layer	Address Resolution Protocol, Serial Line Internet Protocol, Point-to-Point Protocol
Physical Layer	Specifies the network cable, the router, the DSU/CSU box, and the other physical mediums involved.	None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Thank You!