Module 1 : Introduction to Computer Network

Type	Lecture
Materials	https://drive.google.com/file/d/1JbNdvFv3uzdSxKNh4Y2noUafGzfoHqpr/view https://drive.google.com/file/d/1kIRc 76Dn1Bd5qp_5D2IBPeTKDZQGu/view https://docs.google.com/presentation/d/1lnkGtRUVdoP2txk2BeLj92HdR1c S/edit#slide=id.p1 https://docs.google.com/presentation/d/1jbN66cnzWyHguoJBYSEoxfodjUfvPTyd/edit#slide=id.p
Reviewed	☐

Computer Network

> A network can be defined as a group of computers and other devices connected in some way so as to be able to exchange data.

Advantages

- enhances communication and availability of information
- allows for more convenient resource sharing
- makes file sharing easier
- highly flexible
- inexpensive system
- increases cost efficiency
- boosts storage capacity

Disadvantages

- lacks independence
- poses security difficulties
- allows for more presence of computer viruses and malware
- light policing usage promotes negative acts
- requires an efficient handler
- expensive set-up
- lacks robustness

Uses of Computer Network

- **Business Application**
  - Resource Sharing
  - VPNs
  - VoIP
  - Remote Desktop
  - Client –Server Model
- **Home Applications**
  - Peer – to –Peer Communication
  - Instant Messaging
  - Social Networking
  - IP Television(IPTV)
  - Smart Home
- **Mobile users**
  - Hotspot
  - Wi-Fi
  - SMS (Short Message Services)

- GPS(Global Positioning Systems)
- NFC(Near Field Communication)
- Sensor Networks
- Wearable Computers

- **Social Issues**
  - Network Neutrality
  - Digital Millennium Copyright Act
  - Profiling users
  - Phishing

Network Hardware

- Based on **Number of Participants**
  - Point-to-Point → Unicasting
  - Broadcast → Broadcasting & Multicasting
- Based on **Range**
  - ▼ **Personal Area Network (PAN)** → Private

    wireless computers ,keyboard & Mouse Bluetooth embedded headphones
  - ▼ **Local Area Networks (LAN)** → Private

    Privately owned networks within single building.
    - Ethernet : IEEE 802.3
    - Switch
    - Ports
    - VLAN (Virtual LAN)
    - ▼ **Wireless Local Area Network (WLAN)**

      Wireless network technology, such as Wi-Fi
  - ▼ **Metropolitan Area Network (MAN)** → Public / Private
    - WiMAX – High Speed wireless Internet Access – IEEE 802.16
    - 32 to 40 km
  - ▼ **Wide Area Networks (WAN)** → Public / Private
  - ▼ **The Internet** → Public / Private

Network Software

1. **Network Architecture** : multiple layers abstracted from each other
2. **Protocol Stack** : agreement between same layer parties
3. **Protocol Replacement** : must be done without changing service

Protocol

> **A set of rules that govern data communications**
>
> **A collection of rules and conventions as agreement between the communication parties on how communication is to proceed.**

- defines what is communicated, how it is communicated, and when it is communicated
- **syntax + semantics + timing**

Protocol Hierarchies

- purpose of each layer is to offer certain services to the higher layers, shielding those layers from the details of how the offered services are actually implemented.
- Layer n on one machine carries on a conversation with layer n on another machine.

Design Issues for a layer

1. Mechanism of connection establishment → Addressing
2. Rules for data transfer → Protocol
3. Error control
4. Flow Control
5. Multiplexing and De-multiplexing
6. Speed of sender is greater than the receiver
7. Inability of process to accept long message
8. Very expensive to set up connection for each communication process
9. Scalability
10. Routing
11. Confidentiality and Integrity

Service Primitives

- Communication between adjacent protocol layers (i.e. within the same communications node) are managed by calling functions, called Primitives, between the layers.

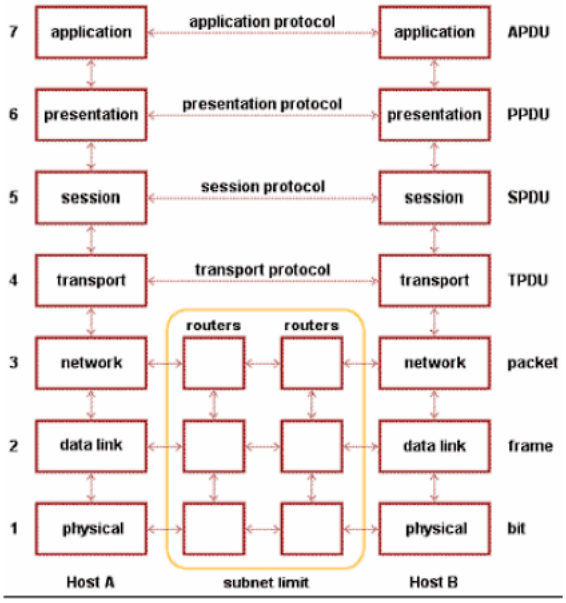
Primitive	Meaning
LISTEN	Block waiting for an incoming connection
CONNECT	Establish a connection with a waiting peer
RECEIVE	Block waiting for an incoming message
SEND	Send a message to the peer
DISCONNECT	Terminate a connection

- A service is formally specified by a set of primitives (operations) available to a user process to access the service.

Reference Models

OSI Model (Open Systems Interconnection)

- 7-layers



1. **Physical Layer**
   - transmit bits over a communication channel
   - establish and terminate a connection to a communications medium
2. **Data Link Layer**
   - means to transfer data between network entities
   - **flow of transmission** and **error detection**
   - Network Layer → Data → Frames → Physical Layer
3. **Network Layer**
   - network routing + flow control + error control functions
   - prevent congestion and bottleneck
4. **Transport Layer**
   - Session Layer → Data → Segments → Network Layer
   - creates a distinct network connections for each transport connection required by the session layer
5. **Session layer**
   - controlling exchange information and for synchronization
   - creating a session dialog control and which allows the user on different machines to establish sessions between them
6. **Presentation Layer**
   - translate different data formats from the representation used inside the computer (ASCII) to the network standard representation and back
   - encapsulation, description, compression and decompression
7. **Application Layer**
   - performs common application service for the application processes
   - **file transfer** as well as electronic mail, remote job entry etc.

TCP/IP Reference Model (Transmission Control Protocol / Internet Protocol)

1. **Host-to-Network Layer**
   - translates data and addresses information into format appropriate for an Ethernet network on Token ring network

2. **Internet layer**
    - connectionless internetwork layer and defines a connectionless protocol called IP
    - permit hosts to inject packets into any network and have them travel independently to the destination
    - does not care about the order the packets
3. **Transport Layer**
    - contains two end-to-end protocols
        1. **TCP (Transmission Control Protocol)**
            - connection-oriented protocol
            - keeps track of the order in which packets are sent
            - reassemble arriving packets in the correct order
        2. **UDP (User Datagram Protocol)**
            - connectionless protocol
            - for applications operating on its own flow control independently from TCP
            - prompt delivery is more important than accurate delivery
4. **Application Layer**
    a. **virtual terminal (TELNET)** → remote accessing on a distance machine
    b. **File Transfer Protocol (FTP**) → move data efficiently from one machine to another
    c. **Electronic Mail (SMTP)**
    d. **Domain Name System (DNS)** → mapping host names onto their network addresses
    e. **HTTP** → fetching pages on the www and others.

Parameters	OSI Model	TCP/IP Model
Full Form	OSI stands for Open Systems Interconnection.	TCP/IP stands for Transmission Control Protocol/Internet Protocol.
Layers	It has 7 layers.	It has 4 layers.
Usage	It is low in usage.	It is mostly used.
Approach	It is vertically approached.	It is horizontally approached.
Delivery	Delivery of the package is guaranteed in OSI Model.	Delivery of the package is not guaranteed in TCP/IP Model.
Replacement	Replacement of tools and changes can easily be done in this model.	Replacing the tools is not easy as it is in OSI Model.
Reliability	It is less reliable than TCP/IP Model.	It is more reliable than OSI Model.
Presentation Layer	Separate	→ Application Layer
Session Layer	Separate	→ Transport Layer
Network Layer	Connection-oriented & Connectionless	Connectionless

Addressing

▼ **Physical Address**

- Physical Layer and Data Link Layer
- ***48-bit (6-byte)*** *physical address written as 12 hexadecimal digits; every byte (2 hexadecimal digits) is separated by a colon*
- Eg : **07:01:02:01:2C:4B**
- **change from hop to hop**

▼ **Logical Address**

- Network Layer
- **remain the same**

▼ **Port Address**

- Transport Layer
- ***16-bit address represented by one decimal number***

▼ **Specific Address**

- Application Layer

Physical Layer

- **Data**
  - Analog: continuous information
  - Digital: discrete information
- **Signal**
  - Analog: infinite levels of intensity over a period of time.
  - Digital: limited number of defined values.
  - Periodic: completes a pattern within a measurable time frame (period) and it repeats.
  - Non periodic: changes without a pattern.
- **Sampling:** Process of recording an analog signal at regular discrete moments of time.
- **Quantization** : the process of mapping continuous amplitude (analog) signal into discrete amplitude (digital) signal

Time Period = 1 / Frequency

Bit Rate = No. of bits transferred per sec

No. of bits for Intensity levels = log2 levels

Transmission Modes

- **Simplex**
  - Unidirectional data transfer.
  - Use the entire capacity of the channel to send data in one direction.
  - E.g. Keyboards, traditional monitors
- **Half-Duplex**
  - Bidirectional data transfer; not simultaneously.
  - E.g. Walkie- talkie
  - Channel capacity= bandwidth * propagation delay
- **Duplex:**
  - Bidirectional data transfer; simultaneous transmission possible.
  - E.g. Telephone networks
  - Channel capacity= 2*bandwidth * propagation delay

Physical Topologies

> ### Define the layout, virtual shape or structure of network.

1. **Mesh Topology**
   - Dedicated point to point link to every other device.

- No. of physical links with n nodes = n * (n - 1)
- No. of physical links (if duplex) = n*(n-1)/2

▼ **Advantages**

- Use of dedicated links eliminates traffic problems.
- Robust
- Advantage of privacy or security
- The network can be expanded without disruption to current uses.
- Point to point links make fault identification and fault isolation easy.

▼ **Disadvantages**

- Requires more cable than the other LAN topologies
- Complicated implementation
- Expensive Hardware.

2. **Star Topology**
   - Each device has a dedicated point-to-point link only to a central controller, called a hub

   ▼ **Advantages**

   - Less expensive than a mesh topology.
   - Robust.
   - Easy fault identification and fault isolation.
   - Easy to install and reconfigure.

   ▼ **Disadvantages**

   - Dependency of the whole topology on the central hub.
   - More cabling is required than ring and bus topology.
3. **Bus Topology**
   - One long cable acts as a backbone to link all the devices in a network
   - Nodes are connected to the bus cable by drop lines and taps
   - **Drop line** : a connection running between the device and the main cable
   - **Tap** : a connector that either splices into the main cable or punctures the sheathing of a cable to create a contact with the metallic core.

   ▼ **Advantages**

   - Works well for small networks.
   - Ease of installation.
   - Requires less cabling than mesh or star topologies.

   ▼ **Disadvantages**

   - Fault or break in the bus cable stops all transmission.
   - Difficult to add new devices.
4. **Ring Topology**
   - Each device has a dedicated point-to-point connection with only the two devices on either side of it.
   - A signal is passed along the ring in one direction, from device to device, until it reaches its destination.
   - Each device in the ring incorporates a repeater.

   ▼ **Advantages**

   - Cable faults are easily located, making troubleshooting easier.
   - Ring networks are moderately easy to install

▼ **Disadvantages**

- Unidirectional traffic. A single break in the cable can disrupt the entire network.

5. **Hybrid Topology**
   - Combination of two or more topologies
     - Tree Topology → Bus + Star

Physical Layer Devices

▼ **Repeater**

- operates only in the physical layer
- **receives a signal and, before it becomes too weak or corrupted, regenerates the original bit pattern**

▼ **Hub**

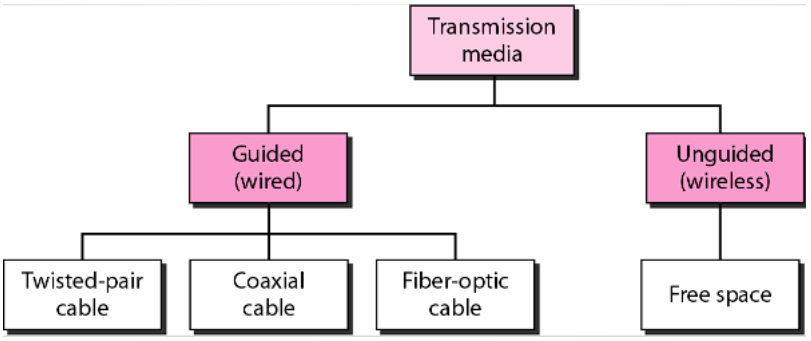
- **connects the wires coming from different branches**

Transmission Medium & Physical Layer

Factors

1. **Bandwidth :** Bandwidth and data rate are directly proportional
2. **Transmission Impairment** : Received signal ≠ transmitted signal
   a. Attenuation
   b. Distortion
   c. Noise
3. **Interference** : Process of disrupting a signal by adding unwanted signals

Classification



▼ Guided Media

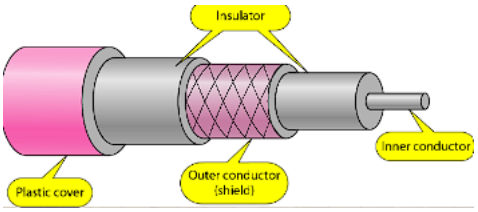
▼ **Twisted-pair cable**

- two conductors, each with its own plastic insulation, twisted together
- One of the wires is used to carry signals to the receiver, and the other is used only as a ground reference.
- **Uses :** Telephonic Applications
- **Problem :** interference, crosstalk
  1. **Unshielded** (UTP)
  2. **Shielded** (STP) → a metal foil or braided mesh covering that encases each pair of insulated conductors

▼ **Coaxial cable**

- A **central core conductor** of solid or stranded wire enclosed in an **insulating sheath**, which is, in turn, encased in an **outer conductor** of metal foil, braid, or a combination of the two
- The outer metallic wrapping → shield against noise + second conductor

- **Uses :** Ethernet LANs, cable TV



▼ **Fiber-optic cable**

- A glass or plastic core is surrounded by a cladding of less dense glass or plastic
- The cladding causes light to be confined to the core of the fibre.

▼ Unguided (wireless)

transport electromagnetic waves without using a physical conductor

▼ **Radio Wave (3KHz to 1 GHz)**

- **can penetrate through walls.**
- used for multicast communications, such as radio and television, and paging systems.

▼ **Microwave (1GHz to 300GHz)**

- **Distance covered is directly proportional to antenna's height.**
- used for unicast communication such as cellular telephones, satellite networks, and wireless LANs.

▼ **Infrared (300 GHz to 400 THz)**

- **Cannot go through obstacles**
- High bandwidth, high data rate, minimum interference.
- used for short-range communication in a closed area (TV remote operation).

Digital to Digital Conversion

1. Line Coding
2. Block Coding
3. Scrambling

Line Coding

- **converts a sequence of bits to a digital signal.**
- **1 → +V & 0 → -V**
- **1 → +V and -V, 0 → -V and +V**

💡 **Data rate / Bit rate :** the number of bits sent per sec - bps.

Signal rate / Modulation rate / Baud rate : the number of signal elements sent in a second and is measured in bauds.

S = c x N x 1/r bauds

N is data rate

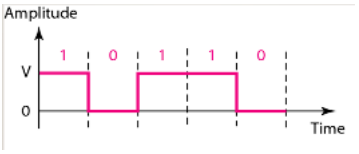
c is the case factor (worst, best & avg.)

r is the ratio between data element & signal element

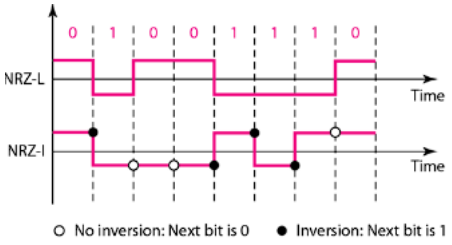
Ratio 'r' : the number of data elements carried by a signal element.

Schemes

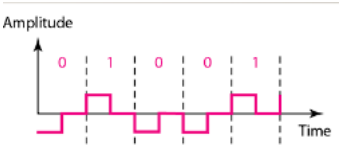
1. Unipolar
    - ▼ **NRZ → Non-Return-to-Zero**
        - Positive voltage defines bit 1 and the zero voltage defines bit 0.



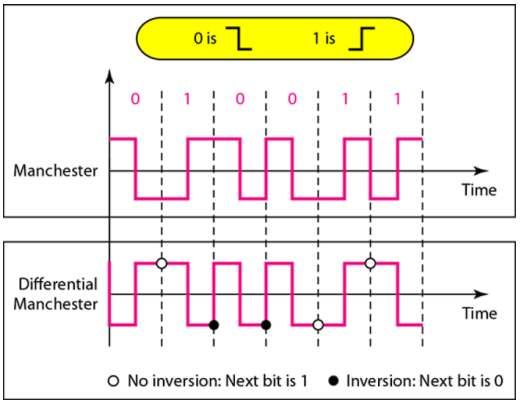
2. Polar
    - ▼ **NRZ → Non-Return-to-Zero**
        - +V for 1 and -V for 0
            1. **NRZ - Level (NRZ-L)** → positive voltage for one symbol and negative for the other.
            2. **NRZ - Inversion (NRZ-I)** → “1” symbol inverts the polarity a “0” does not



    - ▼ **RZ → Return-to-Zero**
        - Each symbol has a transition in the middle



    - ▼ **Biphase**
        - ▼ **Manchester Coding**
            - NRZ-L + RZ schemes
        - ▼ **Differential Manchester Coding**
            - NRZ-I + RZ schemes



3. Bipolar

4. Multilevel
5. Multitransition

Performance Indicators

1. **Bandwidth**
    a. in Hz : range of frequencies contained a channel can pass
    b. in bps : number of bits per second that a channel, a link, or even a network can transmit
2. **Throughput**
    - measure of how **fast** we can **actually** send data through a network
3. **Latency / Delay**
    - How long it takes for an **entire message** to **completely arrive** at the destination from the time the first bit is sent out from the source
    - **propagation time** (for a bit) **+ transmission time** (for a message) **+ queuing time** (intermediate / end device) **+ processing delay**
4. **Bandwidth-delay Product (BDP)**
    - **The number of bits that can fill the link**
    - **BDP** = **Bandwidth** (in bps) * **Round Trip Time** (in s)
5. **Jitter**
    - **different packets of data encounter different delays**