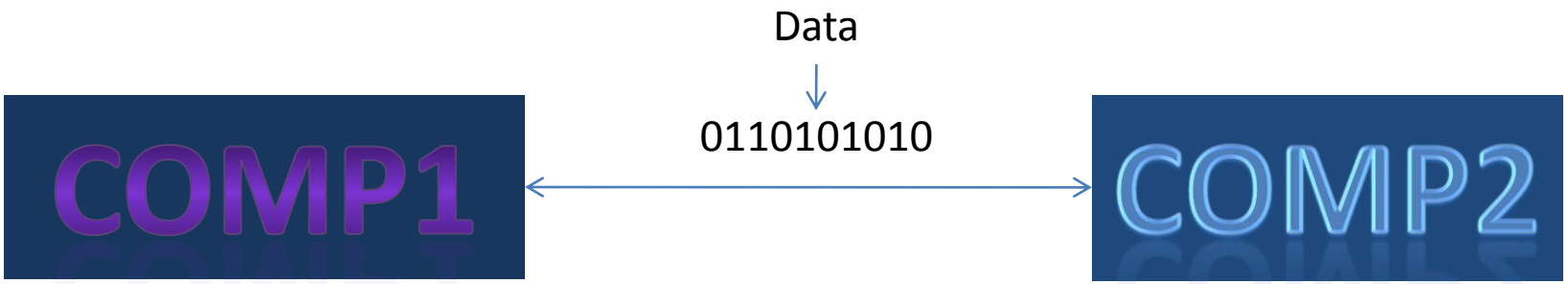
*What is Data Communication?

When two or more computers share data or information with each other then this process is known as Data Communication.



Data communications is the process of using computing and communication technologies to transfer data from one place to another, and vice versa. It enables the movement of electronic or digital data between two or more nodes, regardless of geographical location, technological medium or data contents.

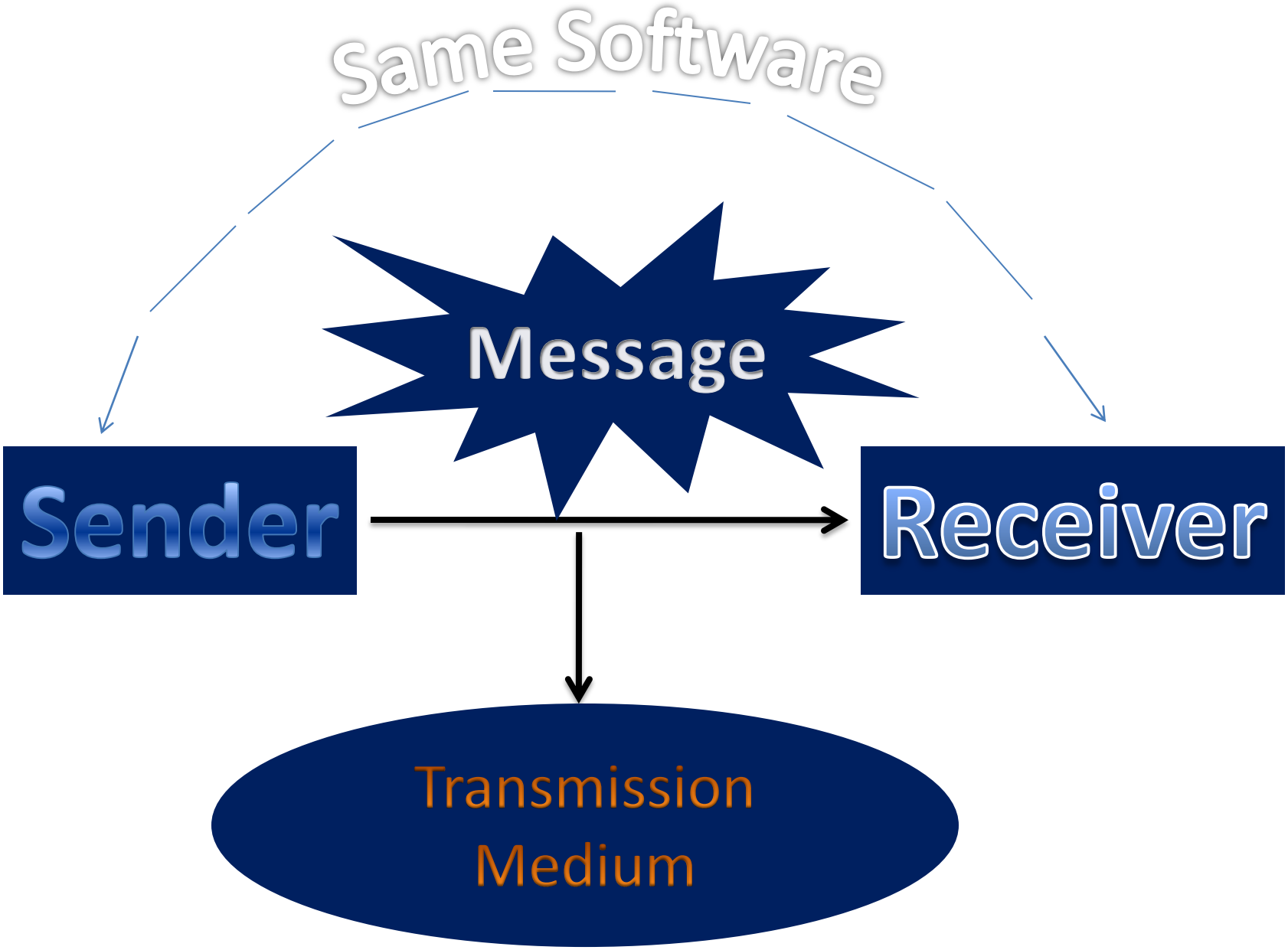
Data communications incorporates several techniques and technologies with the primary objective of enabling any form of electronic communication. These technologies include telecommunications, computer networking and radio/satellite communication. Data communication usually requires existence of a transportation or communication medium between the nodes wanting to communicate with each other, such as copper wire, fiber optic cables or wireless signals.

For Example :- A common example of data communications is a computer connected to the internet via a Wi-Fi connection, which uses a wireless medium to send and receive date from one or more remote servers.

Some devices/technologies used in data communications are known as data communication equipment (DCE) and Data terminal equipment (DTE). DCE is used at the receiving node.

*Components For Data Communication.

- 1. Sender: It is the device which creates the message and sends it to the destination. There is a single sender corresponding to a message.
- 2. Receiver : It is the device which accepts the message from the sender. There can be any number of receivers corresponding to a single message.
- 3. Message: It is the data or the information in form of text, digits, images, audio, video which is created and transmitted by sender and received by receiver.
- 4. Transmission Medium/Hardware: It represents the communication line in form of guided (through wire) or unguided (through air) medium through which data is transmitted from sender to receiver. There may be one or more transmission media that exists between sender and receiver.
- 5. Software: It represents a set of protocols on which the sender and receiver agreed for the communication. **Protocols** is a set of rules which is followed by both the sender and the receiver for the communication. The sender and receiver must agree on same set of protocols to communicate.


Same Software
Message
Sender
Receiver
Transmission
Medium

*DATA REPRESENTATION

- Data that is transmitted by sender through communication medium to the receiver can be done in many ways.

1. Text:

(a) ASCII Code: American Standard Code for Information Interchange.
It uses 7 bits to represent symbols in English text
eg: H- 01001000

(b) Big 5 Code : Uses 16 bits to represent a character

(c) Unicode: Uses 16 bits to represent symbols

(d) EBCDIC : Extended Binary Coded Decimal Interchange Code. Uses 8 bit

2. Numbers:

(a) BCD: Binary Coded Decimal
However the Numbers eg- 0,1,2,……., forms a subset of text.

3. Image : Image can be transmitted in two forms:

(a) Raster Image : It represents image in form of rectangular grid of pixels.
- It may include binary image which can be represented in form of 1 bit.
- It may include gray image which can be represented in form of 8 bits.
- It can also include colour image which can be represented in form of 24 bits.
(R, G, B code format)

(b) Vector Graphic Image : It stores images in form of lines, shapes and colors of objects in an image.
eg- GIF, JPEG and TIFF

4. Sound : It composes of simple waves.
eg – MP3, AIFF, MIDI

5. Video: It composes of sequence of images and sound in proper synchronization manner.

Eg- MPEG (Moving Pictures Experts Group)
AVI (Audio Video Interleaving)

Thus it forms a combination of Audio and Image.

*Data Flow Networks

Many devices are connected together to share the information in a particular topology is called Network. The flow of data within a network can be achieved by the following ways as under:

1. Simplex communication
2. Half-Duplex communication
3. Full-Duplex communication
4. Simplex: In simplex mode the data flows only in direction i.e. it is unidirectional.

Eg- Remote control as shown in fig.

Advantages:

1. It is fast.
2. Accuracy is very high.

Disadvantages:

1. Reverse communication is not possible.

2. Half-Duplex:

In Half-Duplex mode is forward communication or backward but both cannot occur simultaneously.

Eg- Movement of Trains on lane as shown in fig.

Advantages:

1. It is vey fast
2. Accurate as different paths are provided for both movement.

Disadvantages:

1. More cost as multiple paths exits.

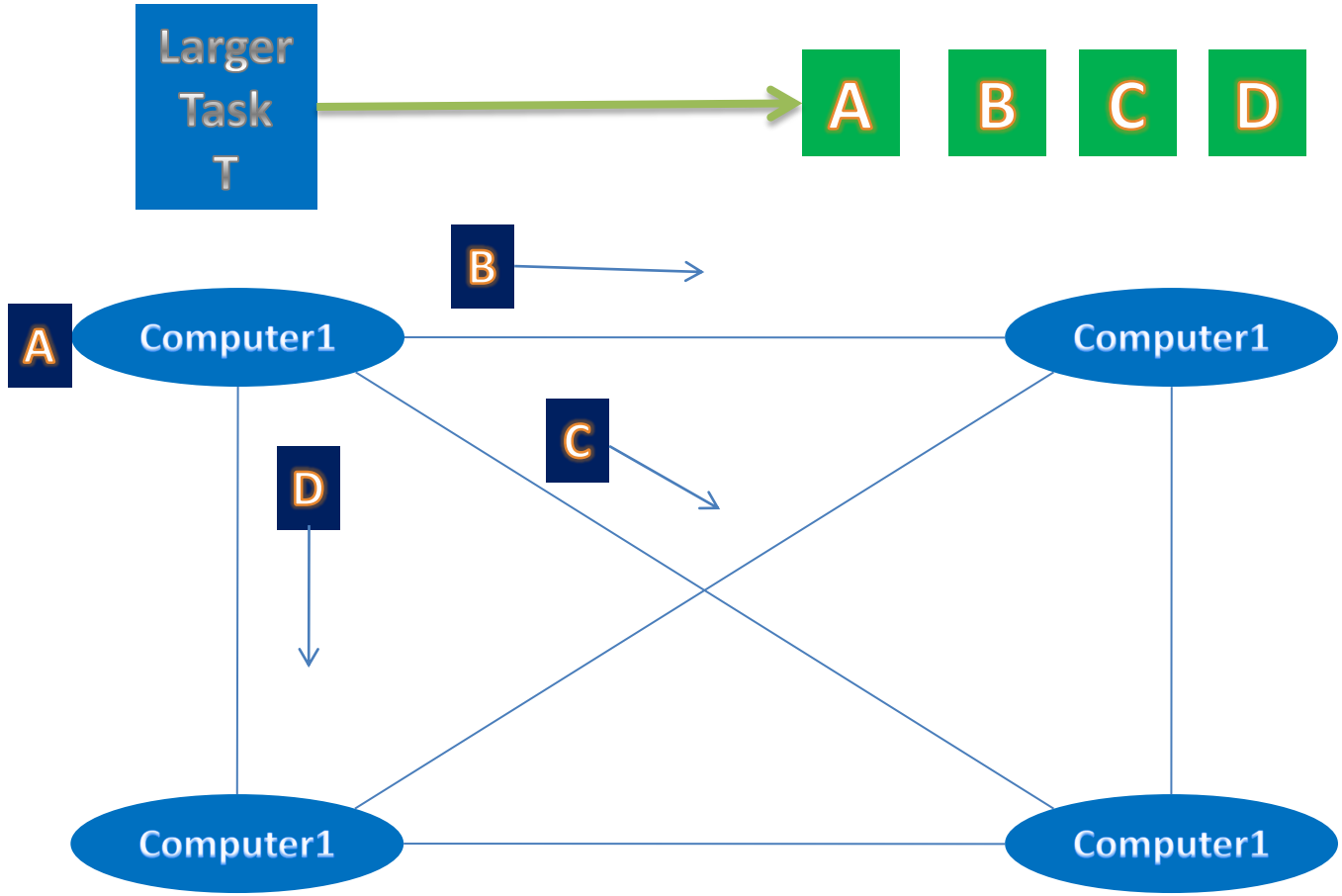
3. Full Duplex:

In full duplex mode both forward and backward movement is possible at the same time i.e. data can flow in both the direction simultaneously. Thus, it represents bidirectional communication.

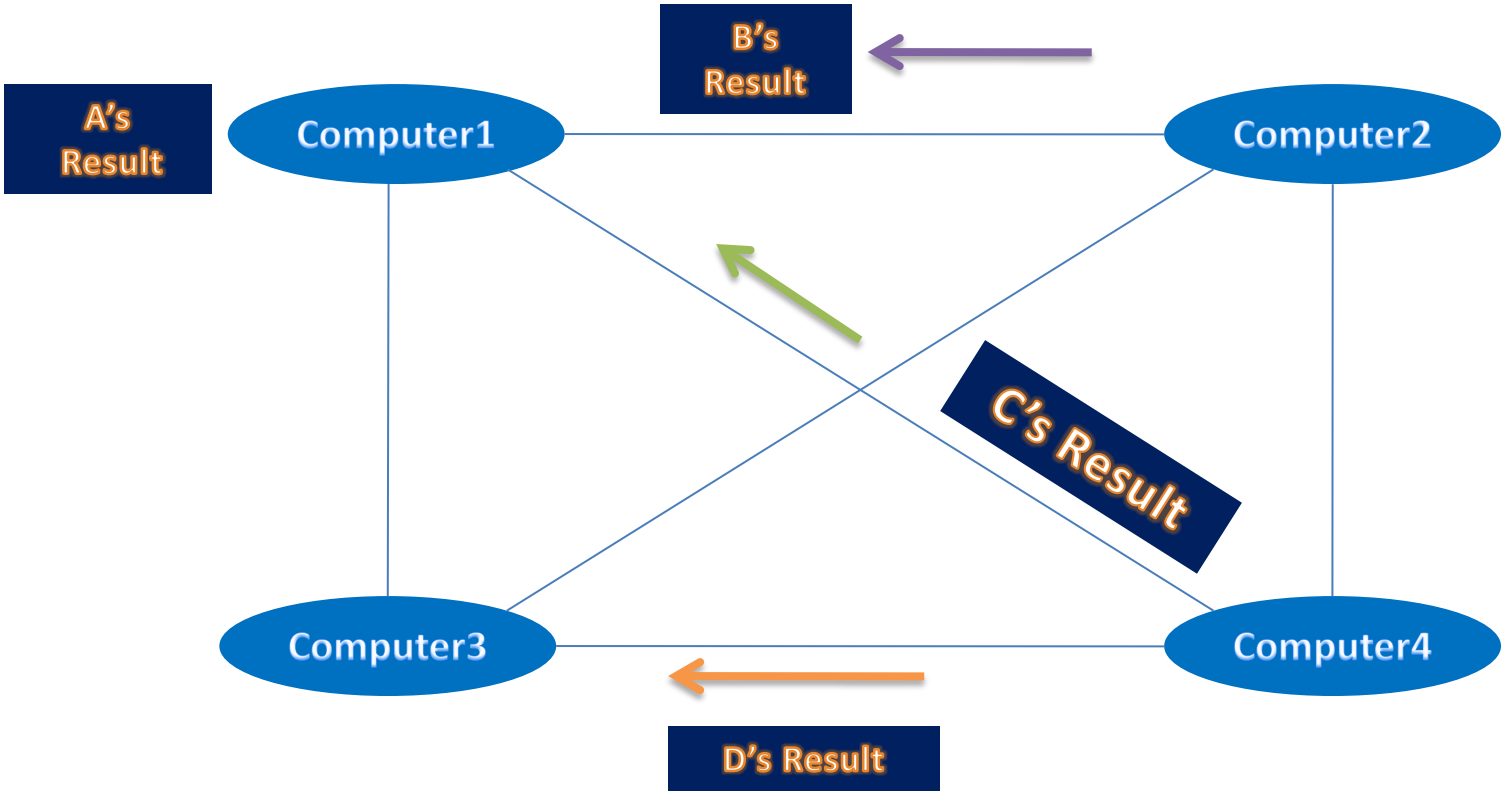
Full Duplex Transmission

*Distributed Processing

- In distributed processing, a large task is divided into smaller subtasks such that they can be executed parellelly. Instead of executing a large task on one device, the smaller subtasks are provided to the different devices on the network through communication line.



Distributed Processing (Assigning Task)



Distributed Processing (Getting Result)

T's result=A's result + B's result + D's result

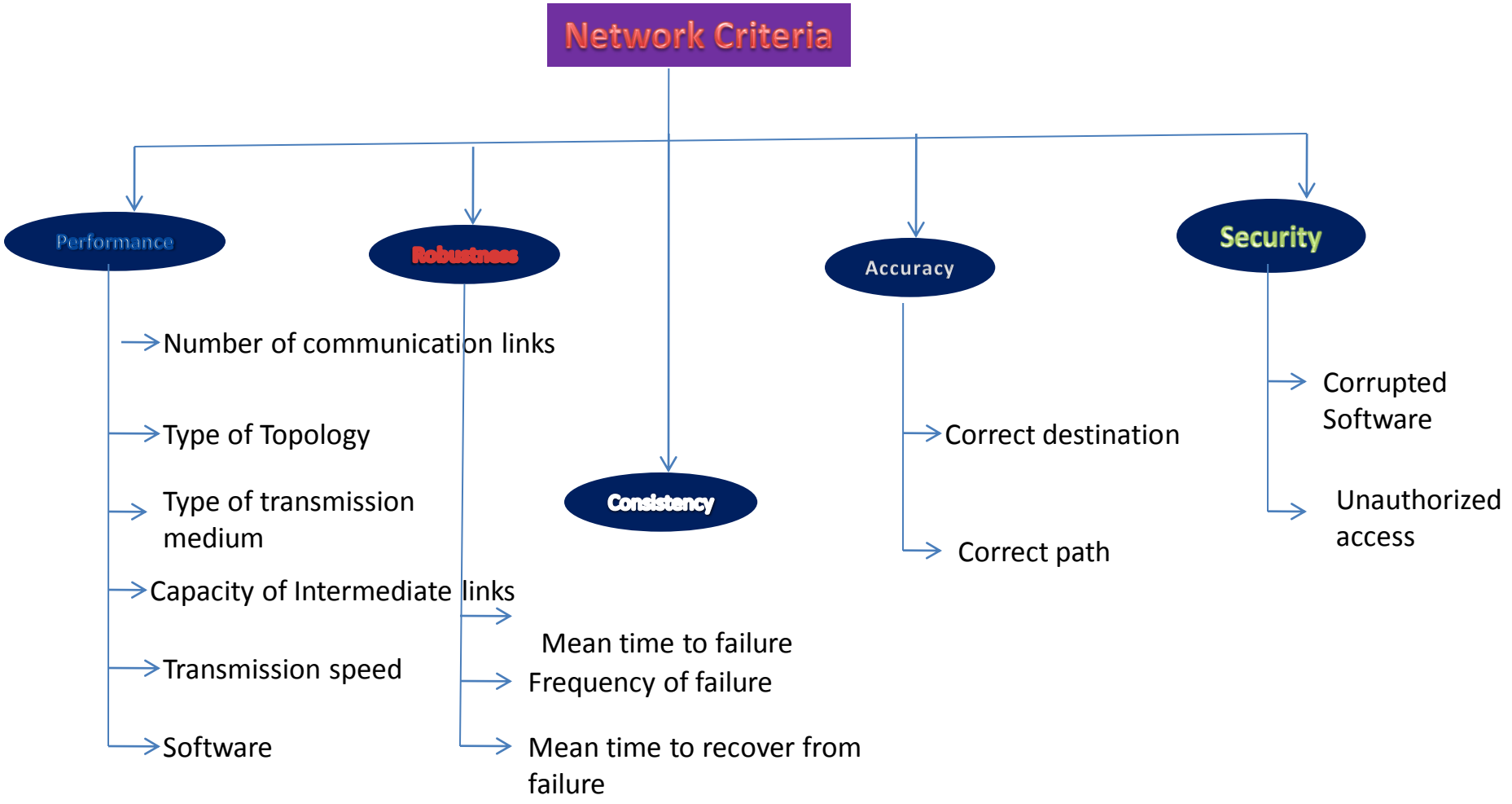
1. Load Balancing: The load is now shifted from single machine to various other machine's due to which nearly equal distributed of loads on all the devices in the network.
2. Faster : Since the load is shared among the devices so execution of subtasks occur in parallel which allows faster execution as compared to the execution of single task on single machine.
3. Higher Resources Utilization : Here the resources are shared among the multiple machine's. So, the chances of machine not in running state is very less due to which utilization of resource increase.
4. Throughput increase: Throughput represents the number of tasks that can be executed by the system. As parallel execution of task takes place here, so throughput increases.

Disadvantages:

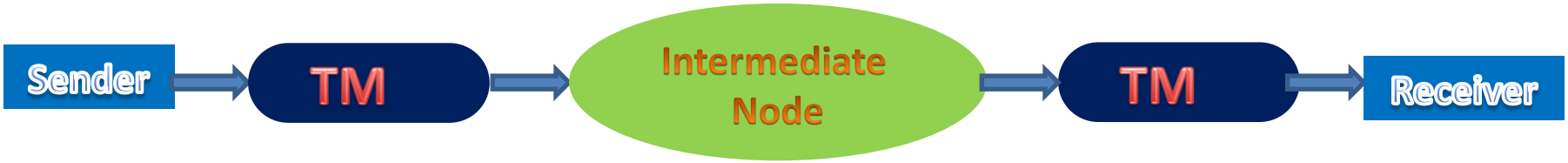
1. Security: As the data is distributed among multiple places so the chances of leakage of information increases.
2. Difficult to maintain same copies at multiple locations: Change at one place needs changing at all other similar locations to maintain consistency in the network.

*Network Criteria

Network must provide some parameters for the efficient communication between the sender and receiver as shown in table.



1. Number of Communication Links: It describe the numbers of users connected to particular node.
2. Type of topology: Topology is the organization of various nodes in the network, how they are connected to one another.
3. Type of Transmission Medium: Transmission medium may be guided or unguided that can exist between the sender and receiver for the traversal of data.
4. Capacity of intermediate links: The intermediate nodes are the nodes present in the network between sender and receiver. The sender transfers data to the intermediate node depending on its capacity to receive the data and it will further send the data to the receiver depending on its capacity to send as shown in fig.

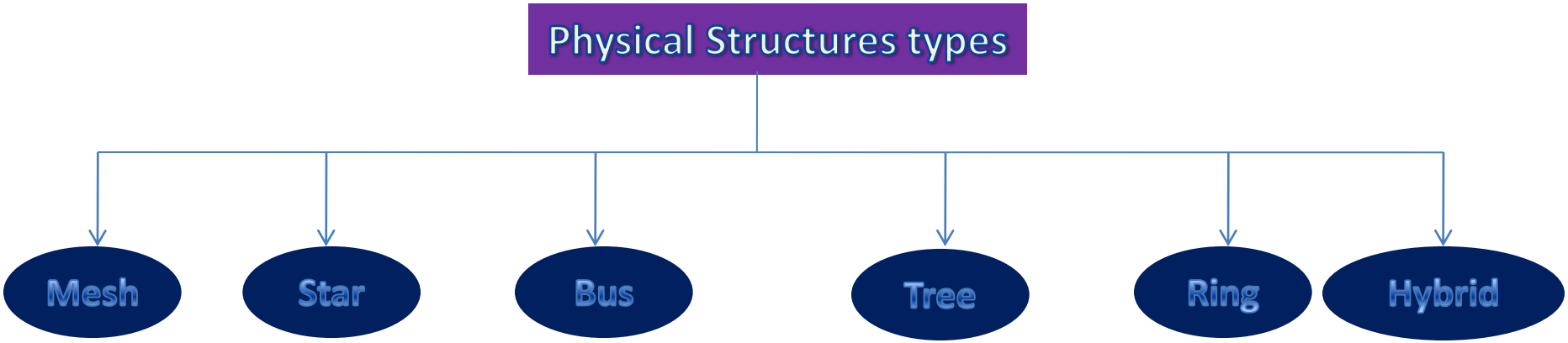


Transmission using intermediate links

5. Transmission Speed : It is the speed with which data can be transmitted from one place to other.
6. Software : Performance depends on the set of protocols on which both sender and receiver have agreed to.
7. Mean time to failure : It describe the mean time taken by the network between the two failures that occur in the network.
8. Frequency of Failure: It describes the times a network fails in a particular period of time.
9. Mean time to recover from failure : It describes the time that is required to recover the network after any failure. Lesser will be the frequency of failure, more will be the robustness of the network.
10. Response Time : Time elapsed between enquire and response. At peak load, there are large number of users and thus the performance decreases.
11. Accuracy : It means the data must be received in the some form as is send by the sender without any change.
12. Transit time : Amount of time required for a message to travel from one device to other.
13. Correct destination : The data must be forwarded to the correct recipient for whom the data was send by the sender.
14. Correct path: During transmission of data, the shortest and minimal cost path must be taken.
15. Corrupted software: The software using which the communication is achieved must be accurate such that it should not corrupt the other applications.
16. Unauthorized access: The legal users can only interact within the network. Any unauthorized access must be prohibited.

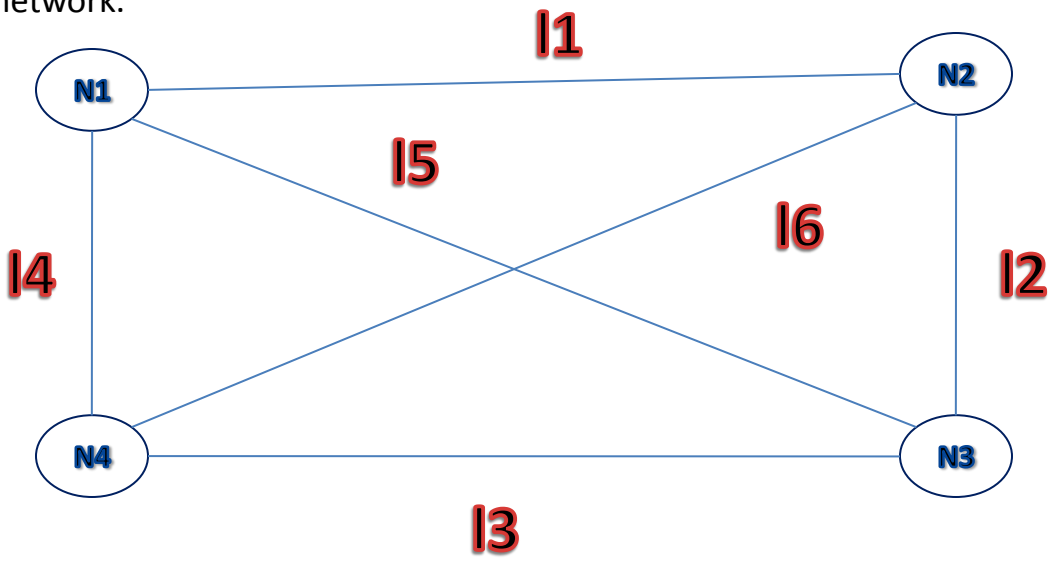
*Physical Structures

Physical structures or topology means how two or more devices are connected to one another to form a network. All the devices in network are known as nodes and the communication medium is represented by links.



Mesh

In mesh topology, each and every device is connected to every other device in the network. Here a separate line exists between two nodes due to which there is no sharing of link. For nodes in network, there are n(n-1)/2 links for a mesh network.



No. of nodes = 4

No. of Links $= \frac{4(4-1)}{2}$

$=2*3$

$=6$

Advantages :

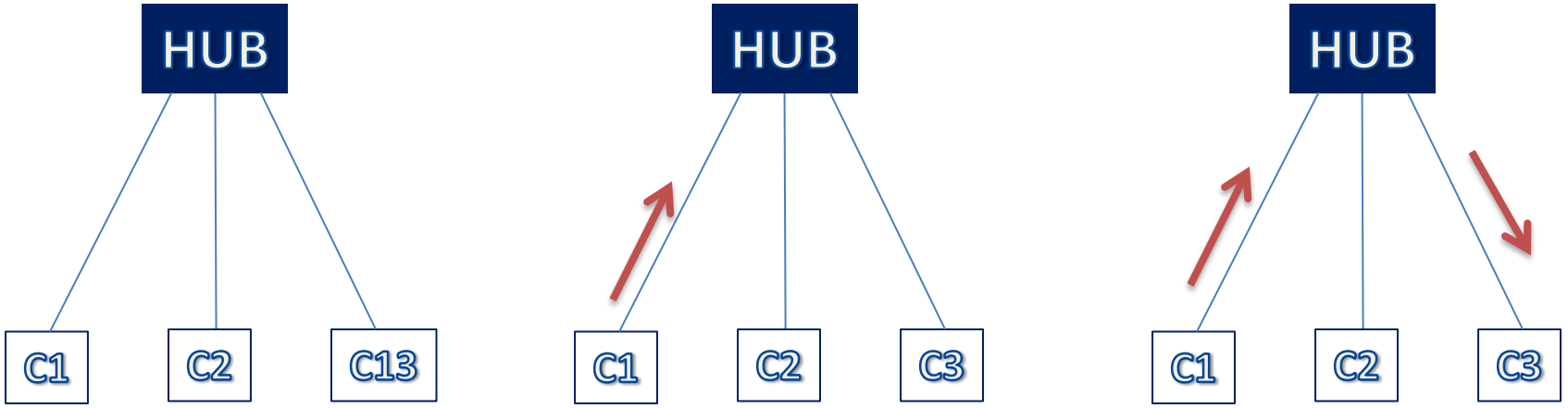
1. No sharing of link, so no data traffic at single link.
2. Connections are reliable as failure of one link doesn't affect the other links in the network.
3. Security : No sharing, so it prevents any leakage of information.
4. Easy to detect and recover faults.
5. Number of alternative paths available between two nodes is more, so flexibility is large.

Disadvantage:

1. Expensive : No. of cables required is large in number.
2. Large space is required for multiple paths between the nodes.
3. Expensive hardware to connect multiple ports for many links through a node.

Star Topology

Here a central third party called HUB that is used as an intermediate for the communication between two or more nodes.



Advantages :

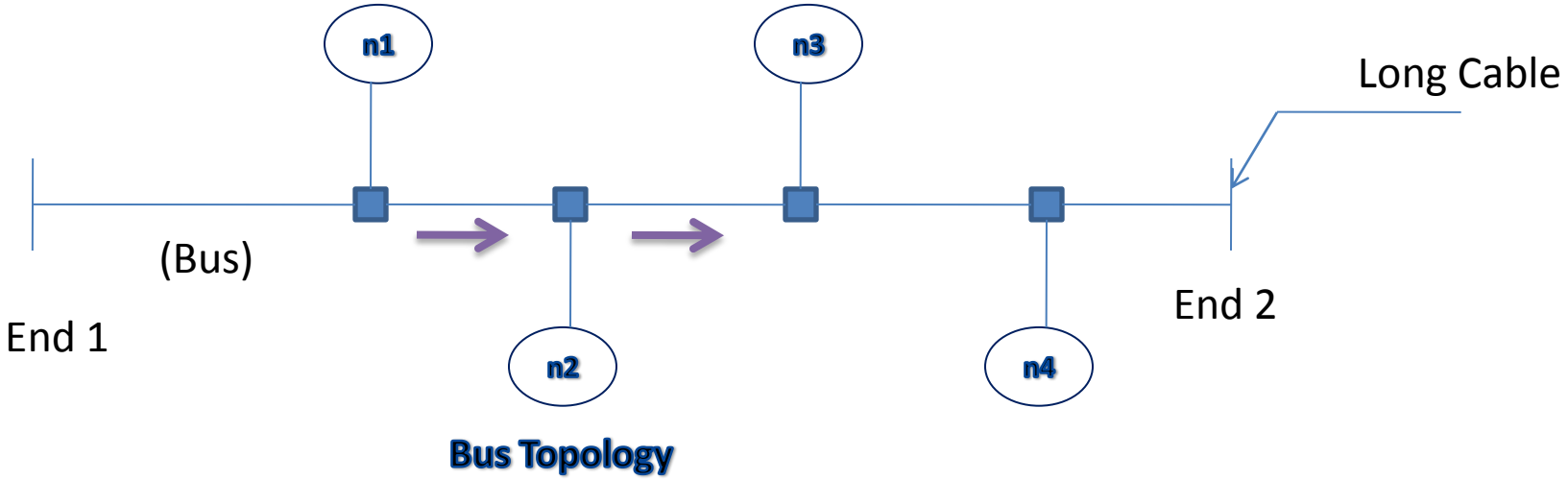
1. Less expensive as it requires less cables tan mesh.
2. If any one link fails, other links are not affected by it.
3. Easy to detect and recover faults.
4. Require less storage due to single path between the two nodes.

Disadvantages :

1. As a third party called HUB is involved in communication then there are chances of leakage of information security is less.
2. If HUB fails whole network will fail.
3. Sharing of link exists here so data traffic may occur at HUB.
4. Only a single paths exists between every two nodes so no flexibility of alternative routes.

Bus Topology

All the nodes are connected to one another through a long cable connecting nodes at various points. There is single cable connecting all the nodes so congestion (data traffic) can occur at any place.



Advantages :

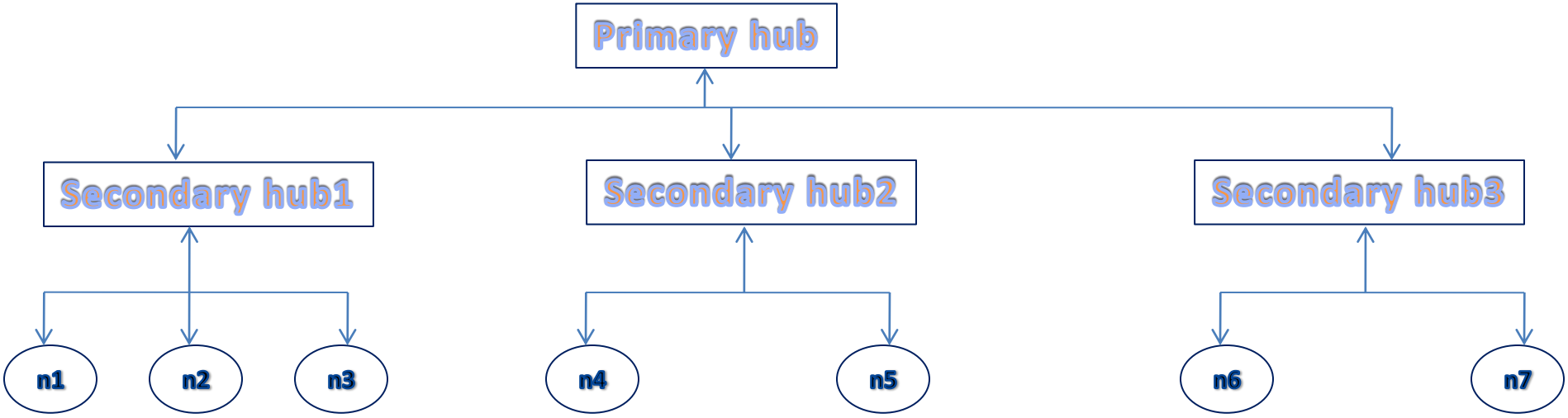
1. Less expensive then mesh as it requires less number of cables.
2. Adding and removing of nodes to and from the network is easy.
3. Easy to detect and recover faults within the network is easy.
4. Less space is required as number of alternative paths is exactly one between two nodes.

Disadvantages :

1. Limited number of users can exist.
2. Performance is degraded as the distance of the node from sender increases.
3. Message is passed to intermediate nodes while transmission of message so, security less.
4. Fault in any line on the long cable can fail the whole network.

Tree Topology

It represents the nodes in hierarchical manner in order to connect the nodes in a network. It uses many hubs. At the top the primary hub is attached to the secondary hubs which are further attached to the number of nodes, a secondary hub can support multiple nodes as shown in fig.



Tree Topology

Advantages :

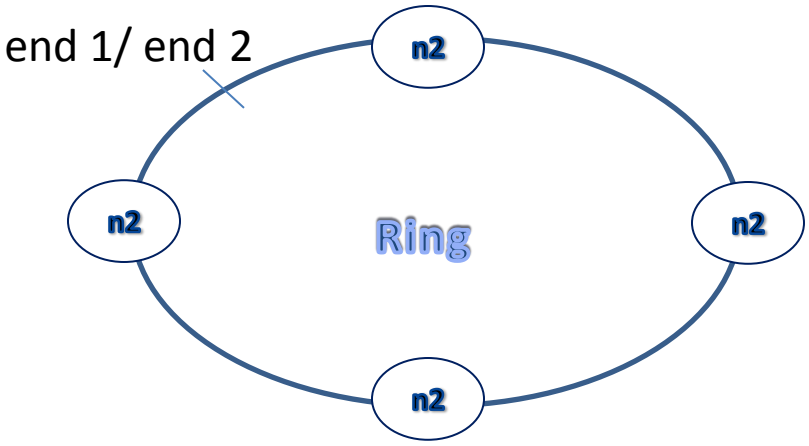
1. Robustness in the network : If one link fails , then other links will continue to work that are not related to that link.
2. Easy to add or remove node in the network.
3. No congestion will occur at any point .
4. Good choice when load needs to be balanced.
5. Easy to detect and recover faults.
6. Less expensive as it requires less cables than mesh.

Disadvantages :

1. Security is affected as both primary and secondary hubs are involved in it.
2. Only single path exists between every two nodes so no flexibility of alternative routes.

Ring Topology

It is similar to the bus topology with only difference that the starting end (end 1) and the other end (end 2) are the same and its unidirectional.



Ring Topology

Advantages :

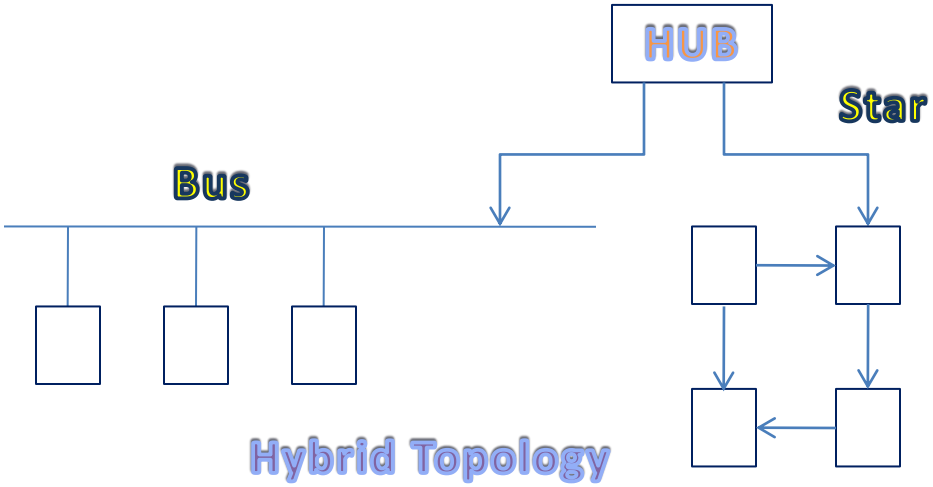
1. Less expensive than mesh due to less number of cables.
2. Adding and removing of nodes to and from the network is easier.
3. Less space is required by the nodes.
4. No congestion in the ring because of token system.

Disadvantages :

1. It can support limited number of users.
2. The message is stored and then forwarded to the next node so higher risk to the security of data.
3. Difficult to detect faults in the network.
4. No Robustness – fault in any lines will fail the whole network.
5. Only a single path exists between two nodes so no flexibility of alternative routes.

Hybrid Topology

If any of the two or more than two topologies are linked together to form a topology then it is termed as hybrid topology as shown in fig.



*Network Category

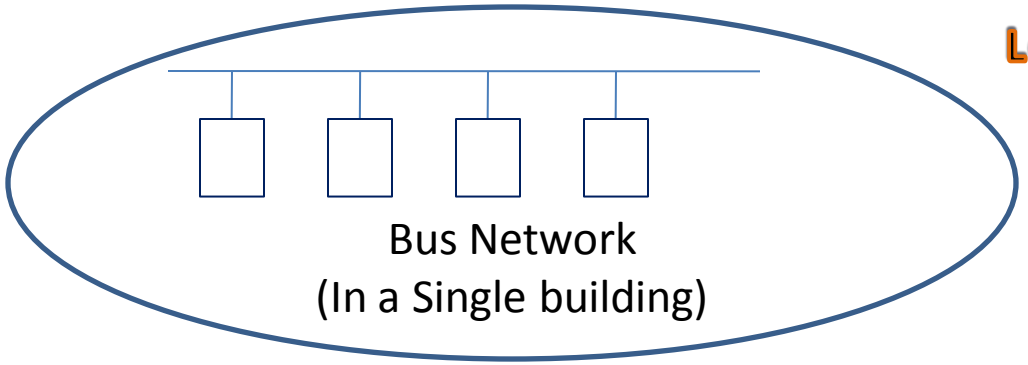
A set of computers or devices connected to one another logically or physically then the devices are said to be connected in a network.

We Categorize the network on basis of size and distance in three types:

1. LAN (Local Area Network)
2. MAN (Metropolitan Area Network)
3. WAN (Wide Area Network)

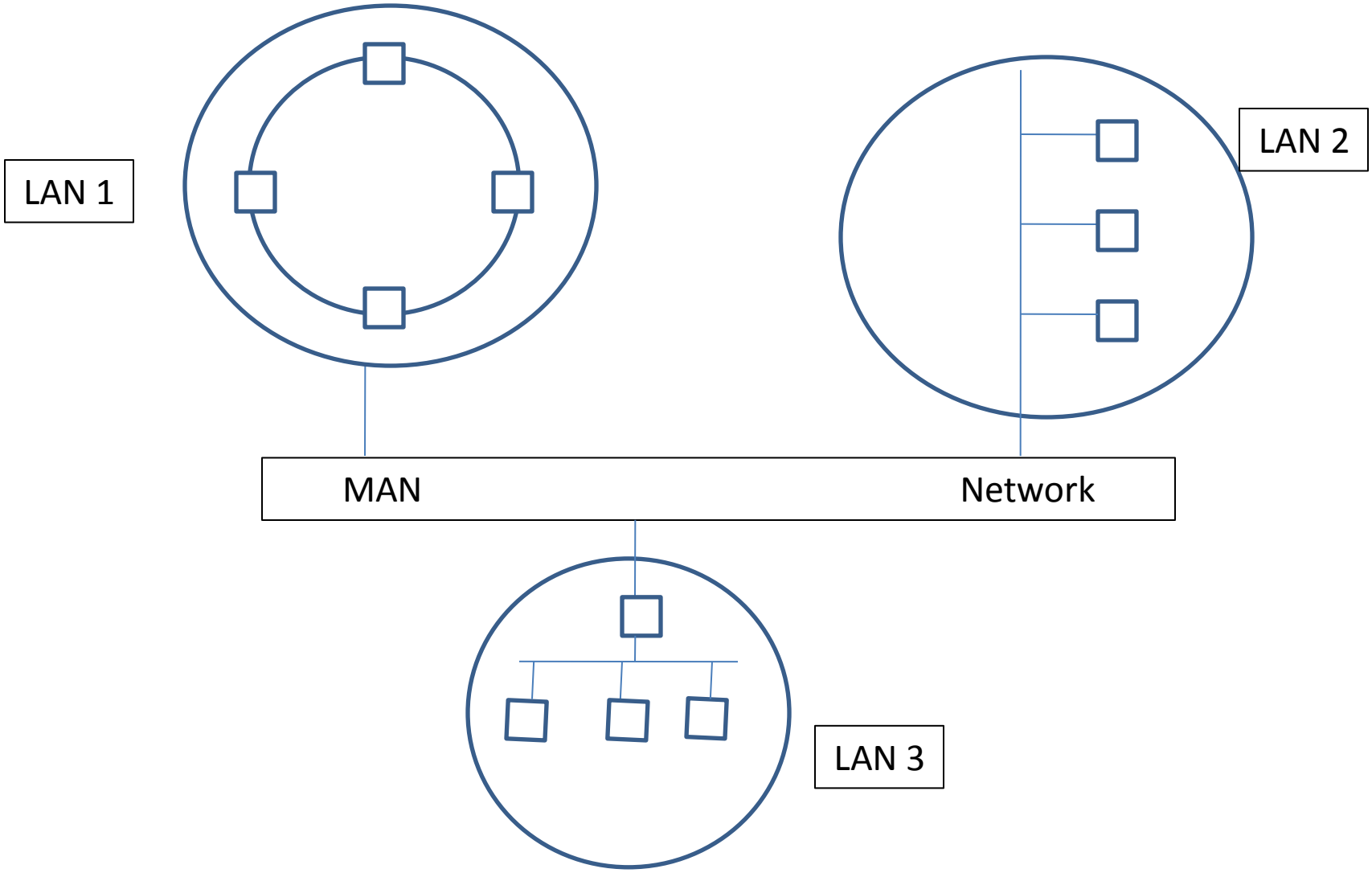
LAN

It is the smallest size network that links various devices restricting them to an office or building. It extends the network to few kilometers. It is used to share resources in form of hardware and software. Due to the restriction in the size, the number of users are limited in LAN. Commonly bus, ring and star topologies are used in LANs for communication. The speed is very fast as compared to other networks.



MAN

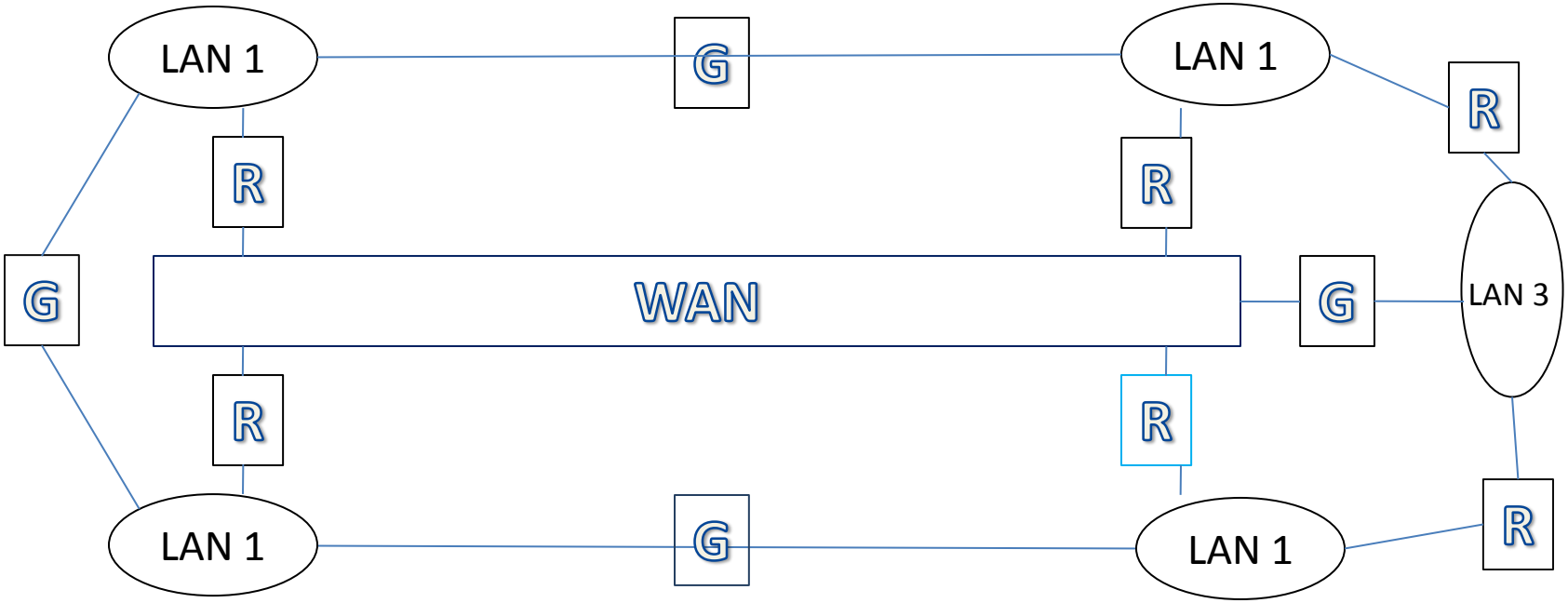
It covers a set of buildings, offices over the entire city. It is a combination of multiple LANs throughout the city.



Metropolitan Area Network

WAN

It covers the largest geographical areas which provides transmission of data all over the world. It support larger number of users as compared to MAN and slower speed with respect to it. It is the combination of multiple LAN and MAN throughout the world as shown in fig. Those LAN and MAN are connected via the Routers or Gateways. Routers and Gateways are the hardware devices based on particular software for intelligent transmission of data between two or more LAN's of different or some architecture and topology.



Wide Area Network

Difference Between LAN, MAN and WAN

As shown in the table the following differences occurs between the local area network, metropolitan area network and wide area network.

LAN	MAN	WAN
1. It is privately owned network 2. It exists within a room or building. 3. Its range is upto few kilometers eg. Km. 4. It can share both hardware and software . 5. Its data rate is very fast. 6. Data can be transferred at occurs here. 7. Smallest size of Network occurs here. 8. It can support limited number of users. 9. It depends on the hardware for data communication. 10. It Offers less cost.	1. It may be privately or publicly owned network. 2. It exists with a city. 3. Its range is upto 100 km. 4. It can transfer data and voice. 5. Its data rate is slower than as in LAN but faster then that of WAN. 6. Data can be transferred at medium speed. 7. Medium size of network occurs here. 8. It can support users more than LAN. 9. It does not depends on the hardware for data communication. 10. It offers more cost.	1. It is always publicly owned network. 2. It exists within country or continent. 3. Its range is >_ 1000 km. 4. It can even transfer multimedia elements. 5. Its data rate is slower than that of LAN and MAN. 6. Data can be transferred at slowest speed. 7. Largest size of network occur here. 8. It can support large number o users. 9. It doesn't depends on the hardware for data communication. 10. It offers very large cost.

Analog and Digital Data

- The Data can be transferred in different form. It may vary at the sender, transmission media or the receive end.

  The Data can be represented in two forms:

1. Analog Data
2. Digital Data

Analog Data

- When the data is represented in continuous manner then it is known as analog data.
- Eg

1. Human Sound : Sound produced by human can take any continuous values.
2. Wall Clock : The time is represented in three forms hour, minute and second where the second’s hand is in continuous movement due to which time changes continuously.

Digital Data

- When the data is represented at discrete states that means data is not continuous but provides value after short internals.
- Eg

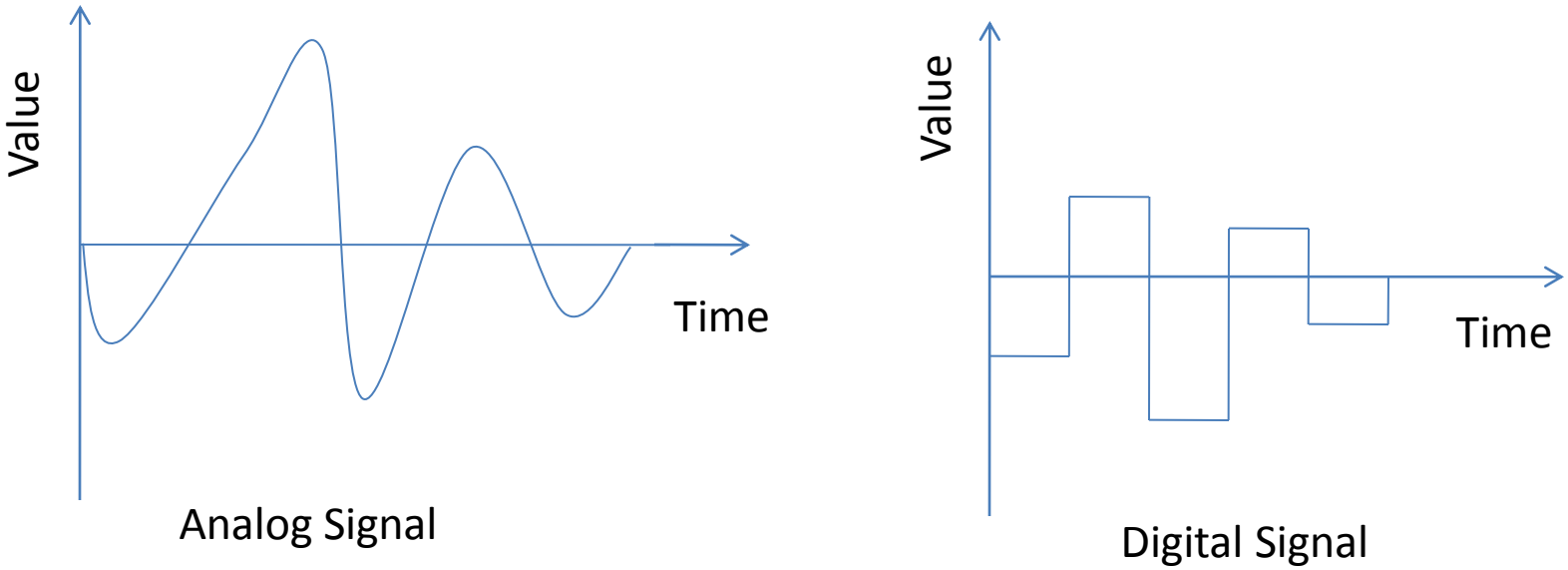
1. Switches : The switch has only two states on and off, it remains off for sometimes.
2. Data stored in computer is in two forms 0 and 1. It can understand only these two bits.
3. Digital clock represents values in form of discrete events. It represents time in form of two parameters hours and minutes. So it changes its values only after 1 min. Within that time the value is same

Note : The Digital Data and Analog Data both can have finite or infinite states.

Analog and Digital Signals

- The data is transferred from sender to receiver in form of signals. On basis of data, signals can be represented in two forms.

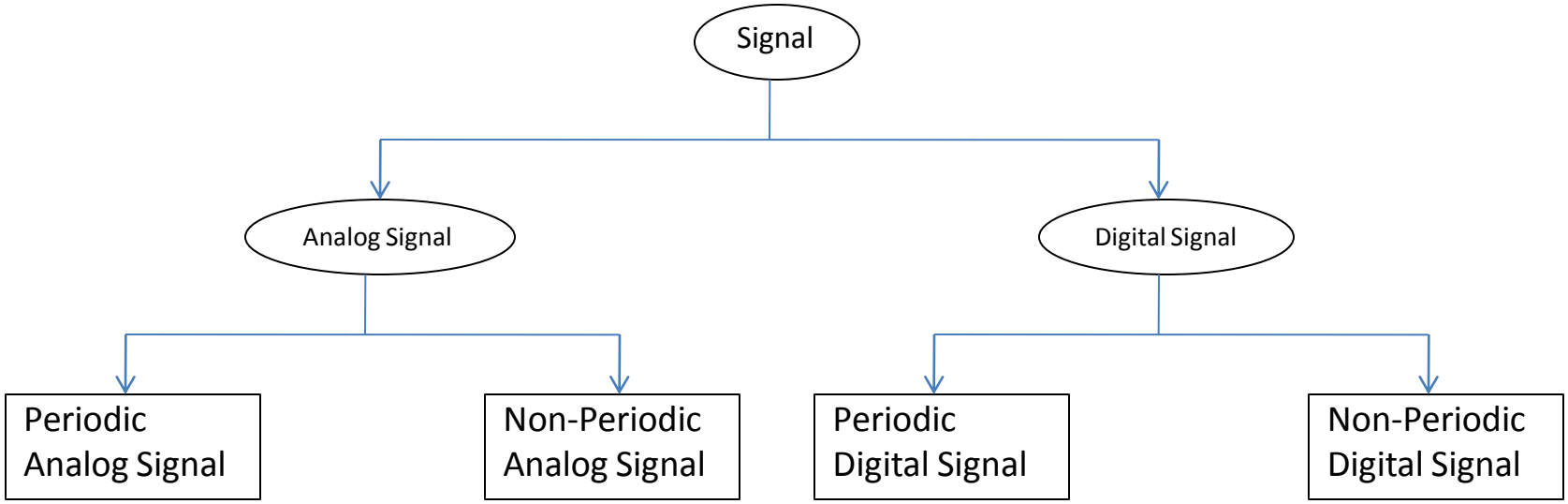
1. Analog Signals : This signal can take infinite number of values during the transmission in continuous manner. It can be represented by plotting a graph with two axis perpendicular with each other. The Horizontal axis shows time while the vertical axis shows the value of the signal.
2. Digital Signals : This signal can take finite number of values during the transmission at discrete events. It can also be represented by plotting a graph as similar to analog signals.



Representing of Analog and Digital Signals

Periodic and Non Periodic Signals

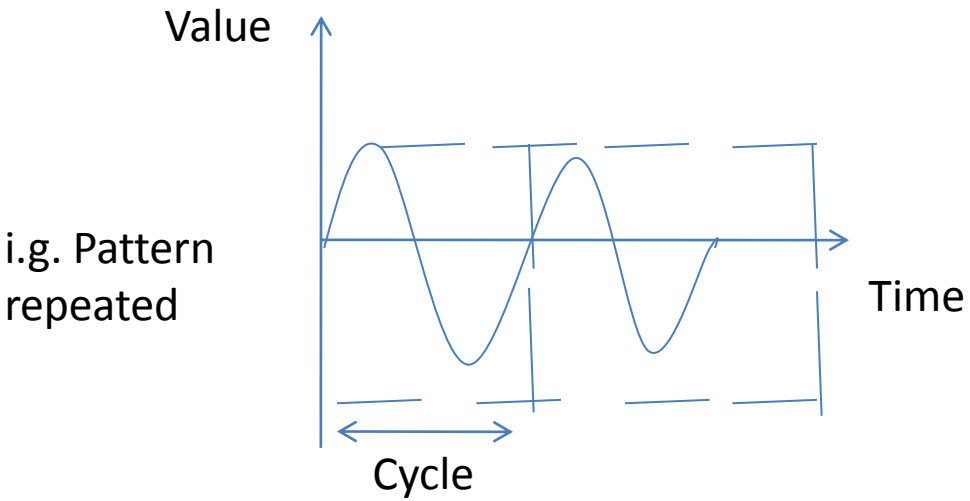
- The classification of signal is as under table



Classification of Signal

Periodic Signal and Aperiodic Signal

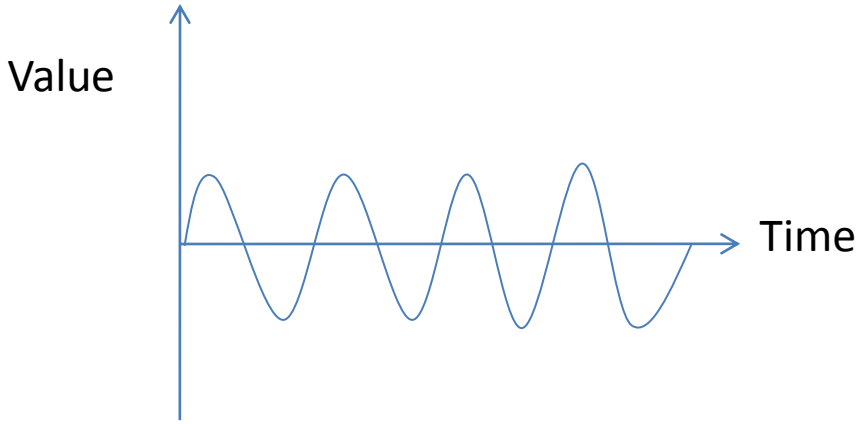
- Periodic Signal : The periodic signals accomplishes a pattern over a certain time interval and continuously repeats the same over a same time.
- Aperiodic Signal : The Aperiodic signals accomplishes a pattern over a certain time internal and may differ in pattern in the next interval.



Representation of cycle

Periodic Analog Signals

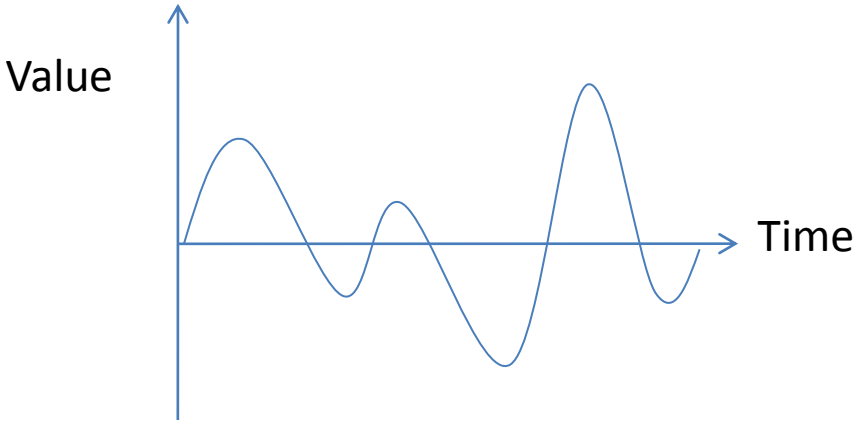
- These are the continuous signals that accomplishes a pattern over a certain time, known as periodic and then continuously repeats the pattern, known as cycle in the same period as shown in fig.



Periodic Analog Signal

Aperiodic Analog Signal

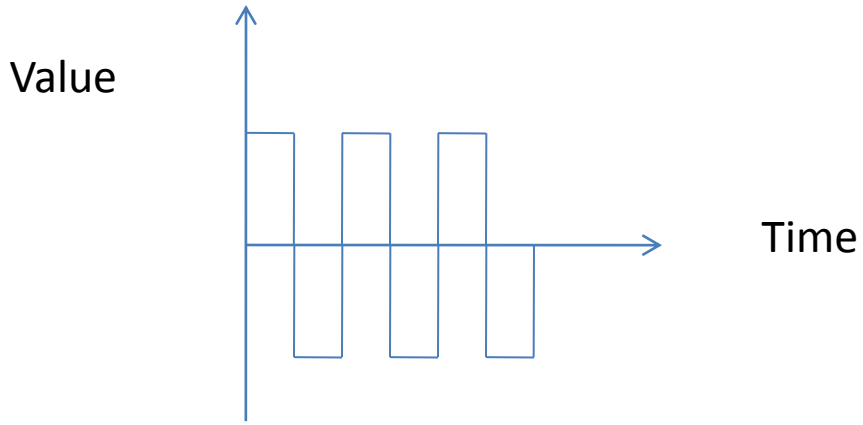
- These are the continuous signals that accomplishes a pattern in a period and then changes the pattern in other interval as shown in fig.



Aperiodic Analog Signal

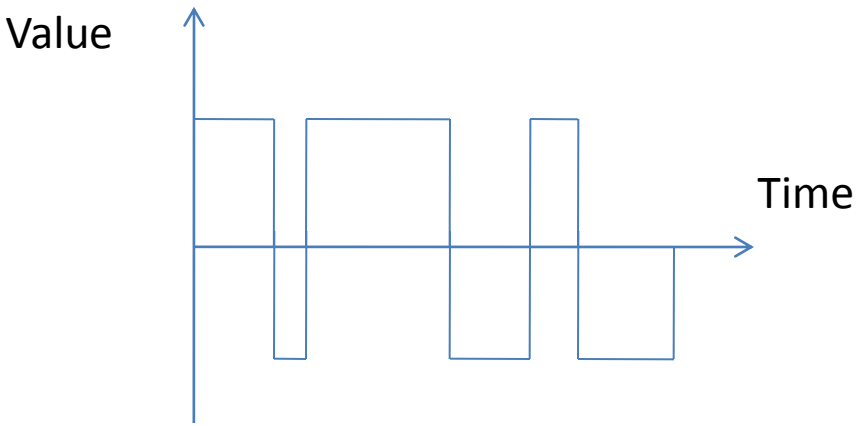
Periodic Digital Signals

- These are the discrete signals that accomplishes a pattern in a period and the represents the same pattern as a cycle in next period. It is different from periodic analog signal in form of discrete nature instead of continuous nature as shown in fig.



Aperiodic Digital Signals

- These are the discrete signals that accomplishes a pattern in a period and then changes the other pattern in next period. It differs from aperiodic digital signal in form of its discrete nature instead of continuous natures as shown in fig.



Periodic Analog Signals

- These are those continuous signals that accomplishes a pattern over a certain time, known as period and repeats the cycle in next periods.

Types of periodic analog signal

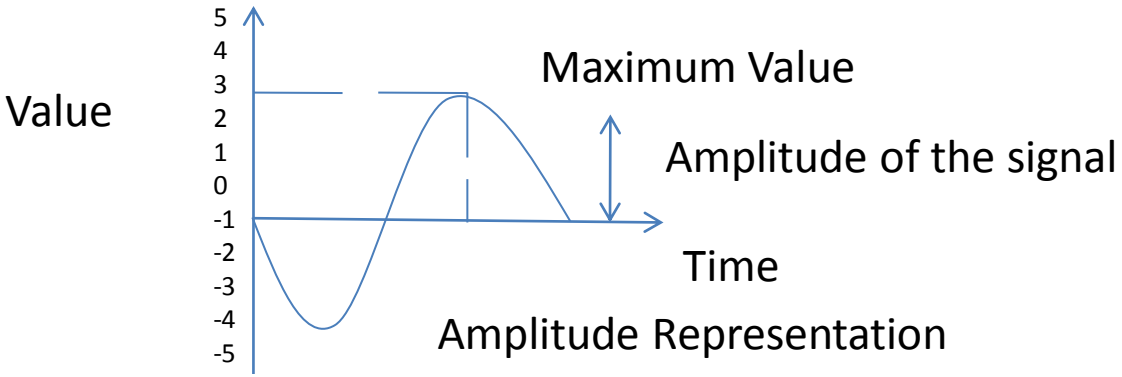
1. Single periodic analog signal
2. Composite periodic analog signal

Single Periodic Analog Signal

- It is the simplest signal in which decomposition is not possible as shown in fig.

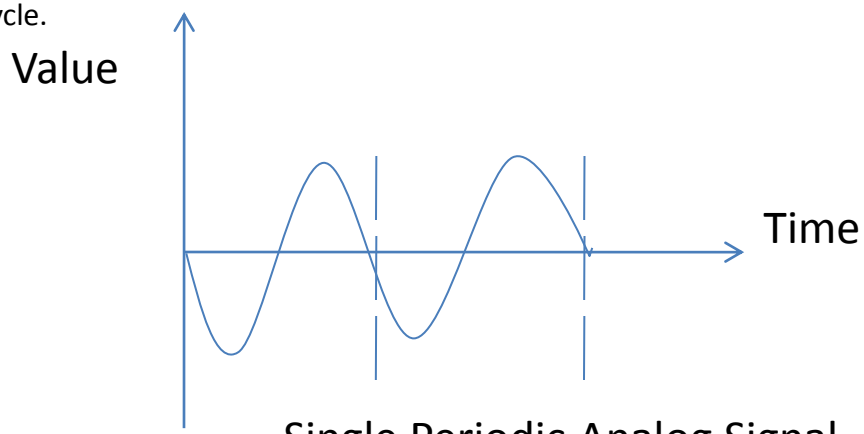
Fundamental properties related to Single Periodic Analog Signal

(a) Amplitude : It represents the highest value or strength of signal where the energy of the signal is maximum.



(a) Phase : It describes the relative position of signal with respect to the original signal. It may be represented in degree(◌) or radians (rad) as shown in fig.

(b) Frequency : It defines number of cycles in one second. However period defines the amount of time required by a signal to cover a cycle.



$$\text{Frequency} = \frac{1}{\text{Period}}$$

Digital Signals

- Digital signals represents information at discrete events. It is not continuous signal as it remains stable an a particular level for a particular time interval instead of ranging continuously at every time.

A digital signals may have two or more than two levels.

1. Bit rate : It is the number of bits that can be transmitted from sender to receiver in one second. It's unit is bits per second (bits/second or bps). The bit rate is different for both sender and the receiver.
2. Bit Length : It represents the length that a single bit occupies when it is transmitted from sender to receiver through the propagation medium. It wraps the period to the speed with which a bit can be translated from sender to receiver (in form of cycles).

Bit length is represented in 2 ways:

1. Bit length = period $_{x}$ propagation speed
2. Bit length = propagation speed/frequency (as period = $\frac{1}{\text{Frequency}}$)

Thus the bit length depends on factors

1. Propagation speed : It is the speed with which the data is transmitted from sender to receiver .
2. Period frequency : Period is the time to cover a cycle and frequency is inversely proportional to period.

Digital Signal as a Composite Analog Signal

- A digital signal acts as a composite analog signal using the foureier analysis. A digital signal can be represented in time and frequency domain. The digital is represented in both time and frequency domain.
- Square Signal

  Digital signal are represented in form of square signals. These square signal consists of multiple square waves that are constructed with addition of harmonics. The harmonics of a digital signal is represented.

Transmission of Digital Signals

- The digital signals are transmitted from transmission media from sender to receiver. The digital information is in form of 0 and 1 but for the transmission they must be converted to the two states using voltage levels.

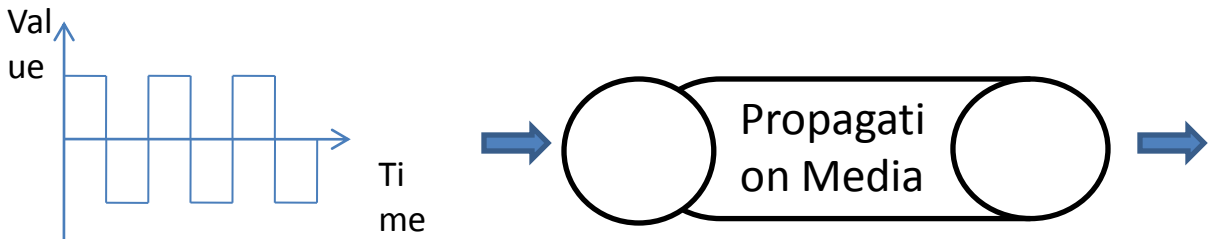
1. Bit 1 represents the higher voltage.
2. Bit 0 represents the lower voltage.

This Transmission of digital signal can occur in two ways.

1. Base band signal
2. Pass band/Broadcast signal

Baseband Signal

- In baseband transmission the data is converted to the digital signals so that they can be transmitted through the transmission medium from sender to receiver.



Broadcast Signal

- In broadcast signal the digital data transmitted is converted to the analog signals so that they can be transmitted through transmission medium from sender to reseiver.

Transmission Impairment

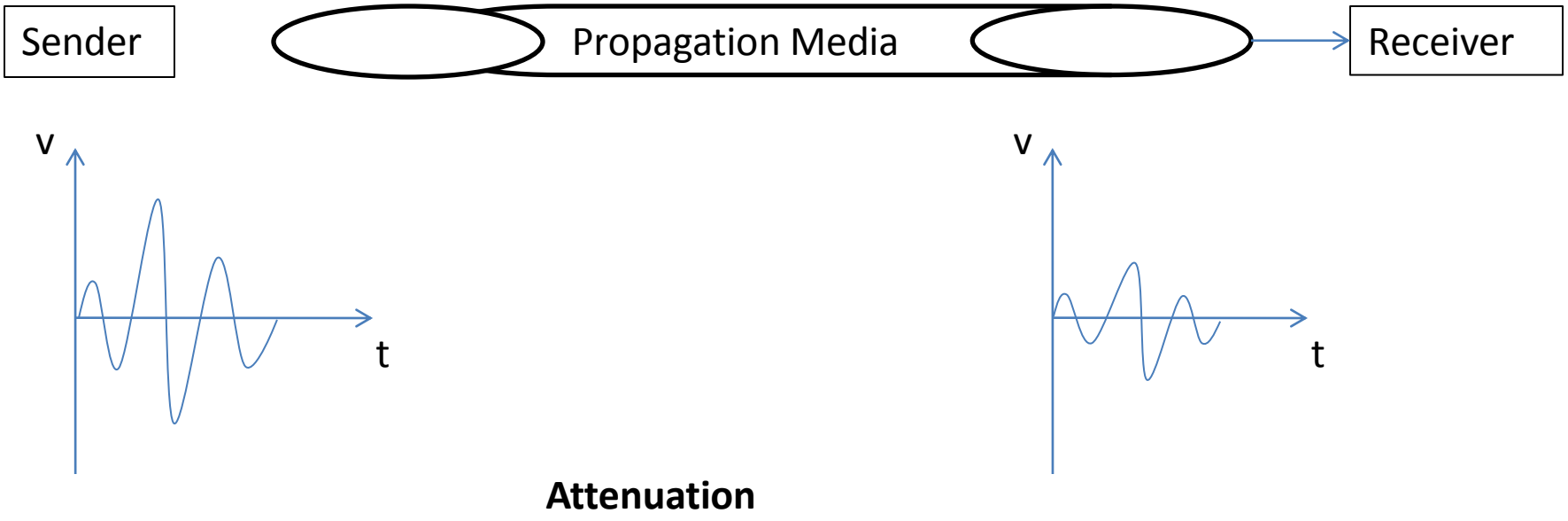
- When the data is transmitted from sender to receiver using some propagation media, the signal received by the receiver is different from the signal send by the sender. This can occur due to physical or environmental condition that supports data propagation.
- The Major factors impairment :

1. Attenuation
2. Distortion
3. Noise

Transmission Impairment Factors

Attenuation

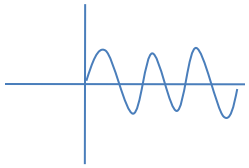
- When the data is transmitted through the propagation media, some energy is lost due to resistive effect produced by the media which converts electrical energy to heat energy. So, the energy of the signal is lost in form of heat energy thus making the signal weak.



Attenuation

Distortion

- During transmission of signal from sender to receiver, the signal changes its shape. It mainly occurs in periodic or aperiodic composite signals, where the different simple signals differ in amplitude and frequency due to which they differ in arriving at the receiver's end.

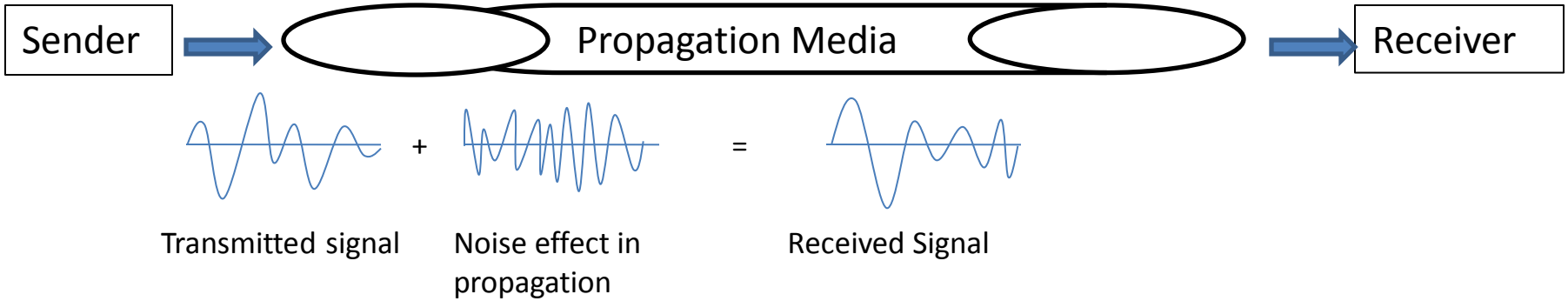


Noise

- It is a unwanted effect that adds to the signal send by the receiver at any place

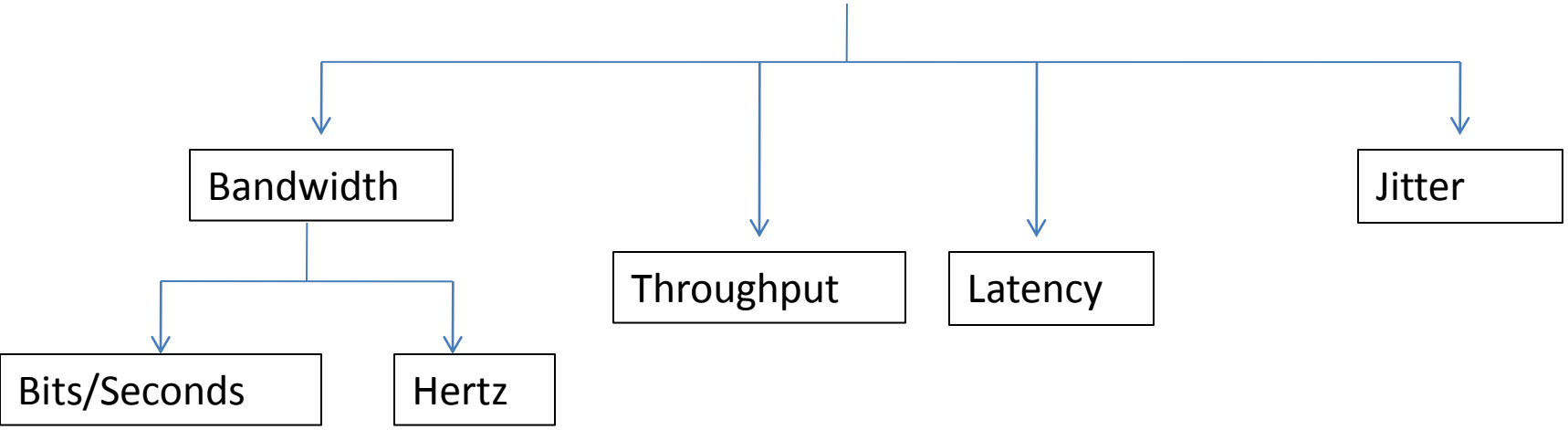
1. At sender side
2. At receiver side
3. During the transmission through propagation medium.

If the noise had made minor changes to the original signal then it can be negleted and it the whole signal.



Performance

- The data transmission is an common phenomenon from sender to receiver but how well this takes place decides its performance. How easily and fastly can the data be transmitted analog with accuracy is most important factor for the performance of a network in which data transmission takes place.



Performance Criteria

Bandwidth

- Bandwidth determines how much amount of data can be transmitted from sender to receiver at a time. With high bandwidth, more data can e transferred due to which performance of the network increases.

It can be measured in two ways:

1. Hertz(Hz) : It allows the signals to transmit multiple range of frequencies through the propagation media.
2. Bits/Second : It determines the number of bits that media can support to transmit the data from sender to receiver at a time. The capacity of each and every media is limited to aparticular extent.

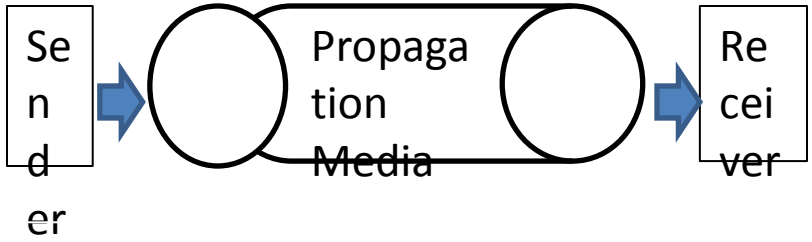
Less bandwidth shared between

More bandwidth shared between sender and receiver

Throughput

- It determines how fastly can the data be transmitted from sender to receiver. Bandwidth determines the capacity of the transmission media but throughput determines the sending capacity of the sender and receiving capacity of the receiver. On basis of how fast sender can send and how fast receiver can receive, decides the throughput of the network.

Case 1- : When limit of sender (s) & receiver (R) Is less that that of communication media.



If Bandwidth is 3bps & capacity of S & R 3bps Then data will be transmitted with capacity 3bps

Case 1- : When limit of sender (s) & receiver (R) Is less that that of communication media.

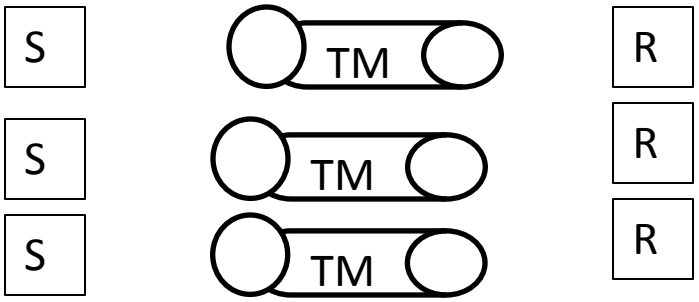
If Bandwidth is 5bps & capacity of S & R 7bps Then data will be transmitted with max. (Capacity of bandwidth i.e. 5bpx)

Latency

- It is the time taken by the whole message to message from the sender to the receiver.

Moreover it depends an four components

1. Propagation time : It is the time taken by a bit of a message to travel from sender to receiver.
2. Transmission time : It is the time taken by a message to travel from sender to receiver.
3. Delay : It is the time taken by sender to get the allocation of transmission medium so that it can send the data and the time taken by receiver to accept and receive the data from transmission media.
4. Waiting time : It is the time spent waiting for the turn to send data on the network. It depends on the traffic or congestion in the network. More will be the traffic, larger will be the waiting time. Less will be the traffic, smaller will be the waiting time.



Jitter

- The problem occurs when we send a message by dividing it into packets and send it using the transmission media to the receiver. The different packets may follow different paths to reach the destination due to which the packets may arrive in different order which hampers the synchronization thus decrease the performance.