DAR ES SALAAM INSTITUTE OF TECHNOLOGY

MODULE: NETWORK MANAGEMENT AND ADMINSTARATION

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TASK: NETWORK PERFOMANCE ON TRANSMISSION MEDIA

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INTRODUCTION TO COMPUTER NETWORKS

Computer Network is a group of computers connected with each other through wires, optical fibers or optical links so that various devices can interact with each other through a network. The aim of the computer network is the sharing of resources among various devices.

In the case of computer network technology, there are several types of networks that vary from simple to complex level.

Networks are typically composed of hardware devices such as routers, switches, and modems, as well as software components such as protocols and network operating systems

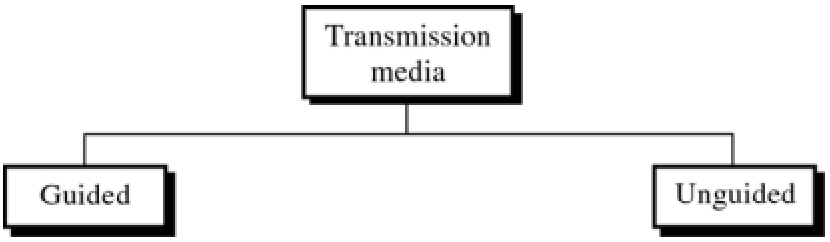
The major components of a computer network include:

1. Devices: These are the physical components that are connected to the network, such as computers, routers, switches, hubs, modems, printers, and servers.
2. Network Interface Cards (NICs): NICs are the hardware components that allow devices to connect to the network. They are responsible for sending and receiving data over the network.
3. Cables and Connectors: Cables are used to connect the devices to the network, and connectors are used to join the cables together.
4. Network Operating System (NOS): This is the software that manages and controls the network, including security, data sharing, and access control.
5. Protocols: Protocols are sets of rules that govern how devices communicate over the network. Common protocols include TCP/IP, HTTP, FTP, and SMTP.
6. Network Topology: This refers to the physical or logical layout of the network, which can be structured as a bus, star, ring, mesh, or hybrid topology.
7. Network Security: This includes measures to protect the network from unauthorized access and to ensure the integrity and confidentiality of data transmitted over the network. It can involve the use of firewalls, intrusion detection systems, and encryption technologies.

TRANSMISSION MEDIA

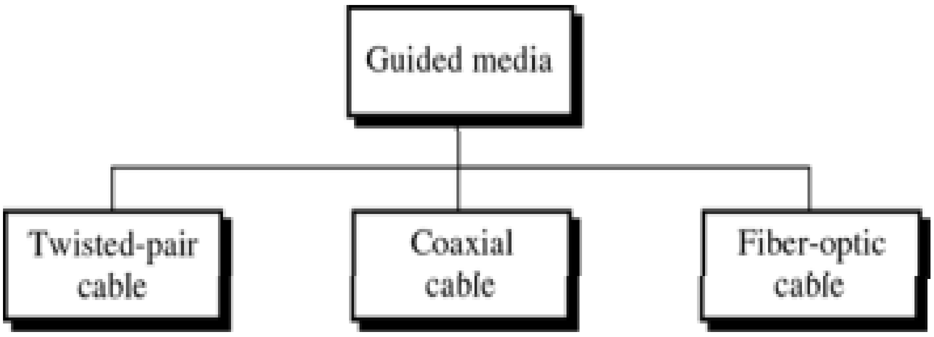
Transmission media refers to the physical channels or paths through which data is transmitted from one device to another in a computer network. From the major components of the computer network transmission media may also be referred as Cables and Connectors.

Classes of Transmission Media



Guided media provide conduit from one device to another, the signal is directed and contained by the physical limits of the medium

Guided media include twisted twisted-pair cable, coaxial cable, and fiber-optic cable.



Twisted-Pair Cable

This is a type of cable that consists of two or more copper wires twisted together. It is commonly used in local area networks (LANs) and telephone systems.

It comes in two forms: unshielded (UTP) and shielded (STP)

UTP

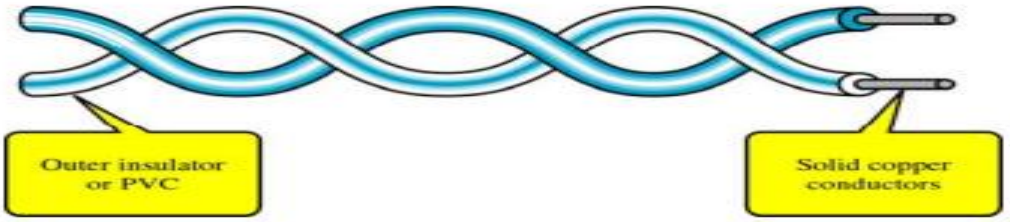
– Most common type in use today

– The plastic insulation is color-banded for identification

– Significantly reduced electromagnetic noise interference compared with two parallel flat wires

– Cheap, flexible, and easy to install

– Five standard categories from Cat. 1 the lowest quality to Cat. 5 the h highest quality

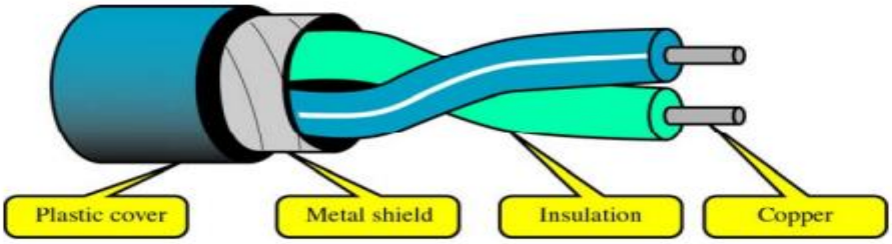


• STP:

– Has a metal foil or braided-mesh covering that encases each pair of insulated conductors

– The metal casing prevents the penetration of electromagnetic noise

– It eliminates most crosstalk



Coaxial Cable

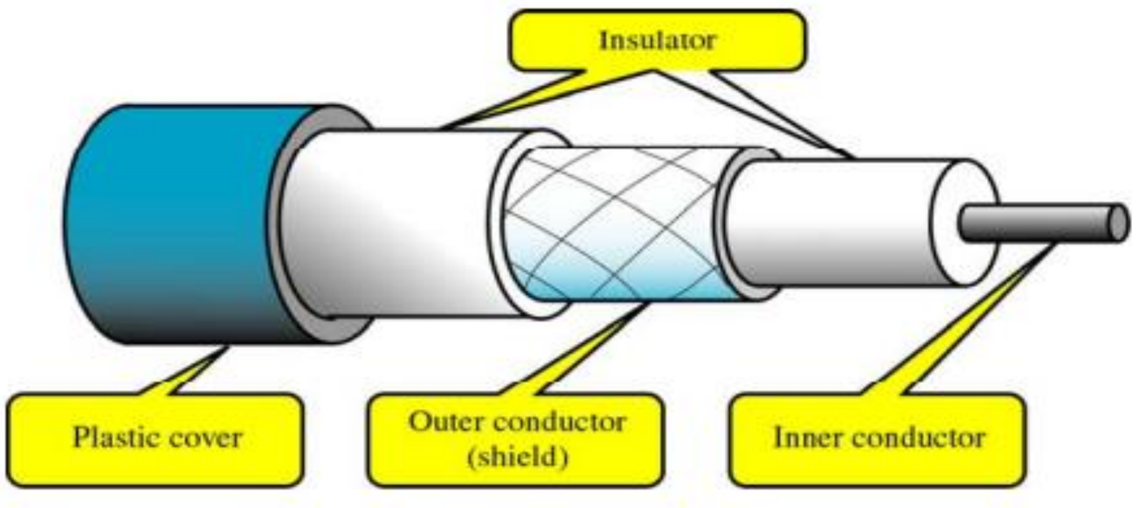
This is a type of cable that has a central conductor surrounded by a layer of insulation and a metal shield. It is commonly used in cable television systems and broadband internet connections.

• Carries signals of higher frequency ranges than twisted-pair cable.

• Uses a central core conductor of solid or stranded wire and an outer conductor of metal foil or braided braided-mesh.

• The outer metallic wrapping serves both as a shield against noise and the second conductor that completes the circuit.

• Coaxial cables are categorized by their RG ratings



Fiber Optic Cable:

This is a type of cable that uses strands of glass or plastic fibers to transmit data as pulses of light. It is commonly used in long-distance telecommunications and high-speed internet connections.

Fiber optic cables offer several advantages over other types of transmission media. They have a higher bandwidth and can transmit data over longer distances without the need for repeaters, which regenerate the signal. They are also less susceptible to electromagnetic interference and have a lower attenuation, which means that the signal does not degrade as much over distance.

How fiber optics works

Fiber optics transmit data in the form of light particles or photons that pulse through a fiber optic cable. The glass fiber core and the cladding each have a different refractive index that bends incoming light at a certain angle.

When light signals are sent through the fiber optic cable, they reflect off the core and cladding in a series of zig-zag bounces, following a process called total internal reflection.

The light signals do not travel at the speed of light because of the denser glass layers, instead traveling about 30% slower than the speed of light.

To renew, or boost, the signal throughout its journey, fiber optics transmission sometimes requires repeaters at distant intervals. These repeaters regenerate the optical signal by converting it to an electrical signal, processing that electrical signal and retransmitting the optical signal.

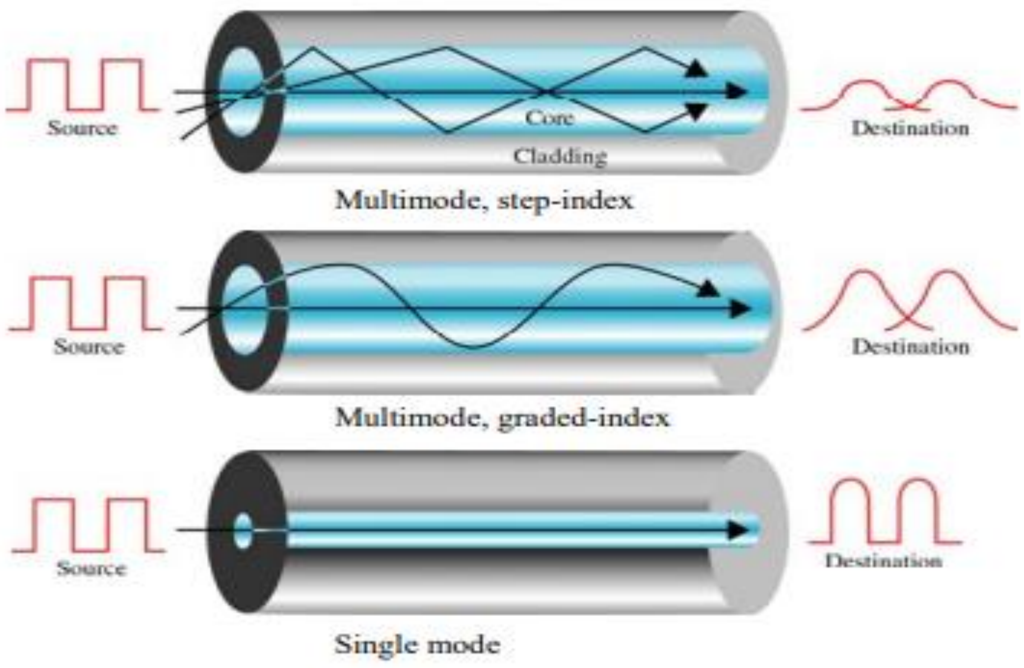
Single-mode fiber

Single-mode fiber is used for longer distances due to the smaller diameter of the glass fiber core. This smaller diameter lessens the possibility for attenuation, which is a reduction in signal strength. The smaller opening isolates the light into a single beam, offering a more direct route and enabling the signal to travel a longer distance.

Single-mode fiber also has a considerably higher bandwidth than multimode fiber. The light source used for single-mode fiber is typically a laser. Single-mode fiber is usually more expensive as it requires precise calculations to produce the laser light in a smaller opening.

Multimode fiber

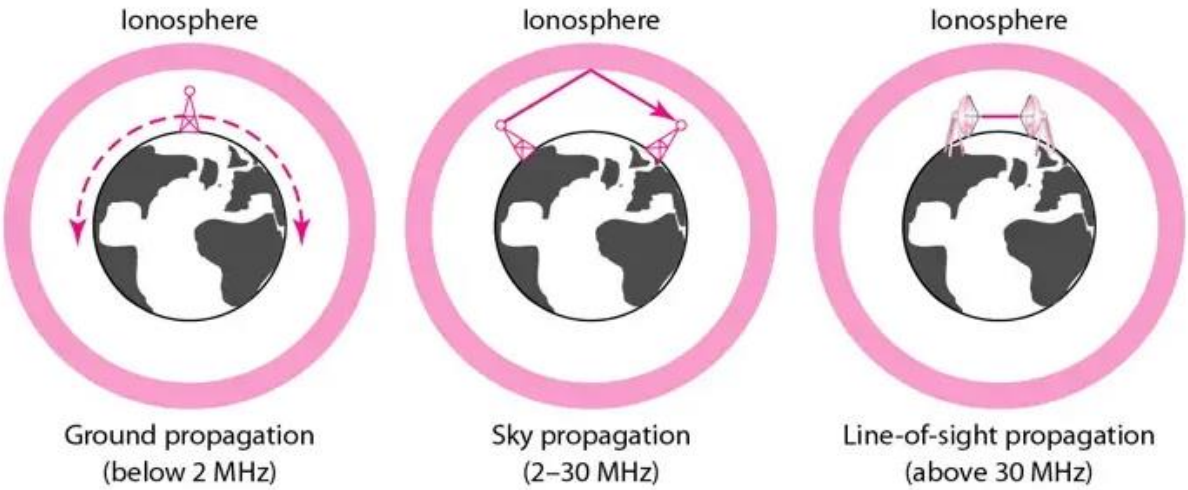
Multimode fiber is used for shorter distances because the larger core opening enables light signals to bounce and reflect more along the way. The larger diameter permits multiple light pulses to be sent through the cable at one time, which results in more data transmission. This also means there is more possibility for signal loss, reduction or interference, however. Multimode fiber optics typically uses an LED to create the light pulse.



Unguided Media

Unguided medium or wireless communication transport electromagnetic waves without using a physical conductor. This type of communication is often referred to as wireless communication. Signals are normally broadcast through free space and thus are available to anyone who has a device capable of receiving them

Unguided signals can travel from the source to the destination in several ways: Ground propagation, Sky propagation and Line-of-sight propagation as shown in below figure.



Propagation Modes

- **Ground Propagation:** In this, radio waves travel through the lowest portion of the atmosphere, hugging the Earth. These low-frequency signals emanate in all directions from the transmitting antenna and follow the curvature of the planet.
- **Sky Propagation:** In this, higher-frequency radio waves radiate upward into the ionosphere where they are reflected back to Earth. This type of transmission allows for greater distances with lower output power.
- **Line-of-sight Propagation:** in this type, very high-frequency signals are transmitted in straight lines directly from antenna to antenna.

We can divide wireless transmission into three broad groups:

1. Radio waves
2. Micro waves
3. Infrared waves

Radio Waves

Electromagnetic waves ranging in frequencies between 3 KHz and 1 GHz are normally called radio waves.

Radio waves are omnidirectional. When an antenna transmits radio waves, they are propagated in all directions. This means that the sending and receiving antennas do not have to be aligned. A sending antenna send waves that can be received by any receiving antenna

Micro Waves

Electromagnetic waves having frequencies between 1 and 300 GHz are called micro waves. Micro waves are unidirectional. When an antenna transmits microwaves, they can be narrowly focused. This means that the sending and receiving antennas need to be aligned. The unidirectional property has an obvious advantage. A pair of antennas can be aligned without interfering with another pair of aligned antennas

Infrared Waves

Infrared waves, with frequencies from 300 GHz to 400 THz, can be used for short-range communication. Infrared waves, having high frequencies, cannot penetrate walls. This advantageous characteristic prevents interference between one system and another, a short-range communication system in on room cannot be affected by another system in the next room.

When we use infrared remote control, we do not interfere with the use of the remote by our neighbors. However, this same characteristic makes infrared signals useless for long-range communication. In addition, we cannot use infrared waves outside a building because the sun's rays contain infrared waves that can interfere with the communication.

NETWORK PERFOMANCE

Network performance is the analysis and review of collective network statistics, to define the quality of services offered by the underlying computer network.

It is a qualitative and quantitative process that measures and defines the performance level of a given network. It guides a network administrator in the review, measure and improvement of network services.

Network performance is primarily measured from an end-user perspective (i.e. quality of network services delivered to the user). Broadly, network performance is measured by reviewing the statistics and metrics from the following network components:

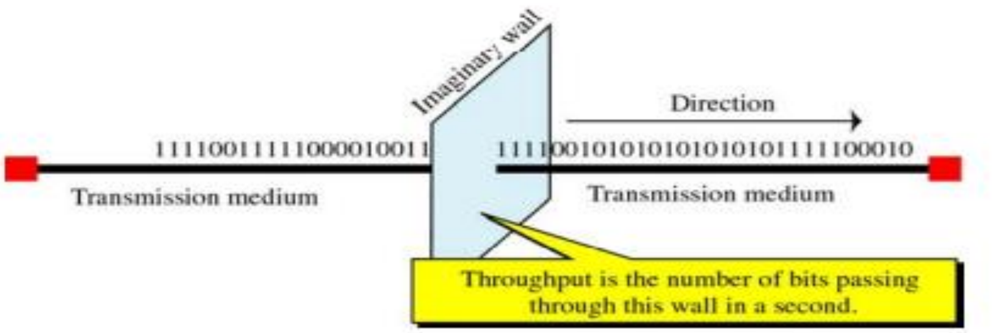
- Network bandwidth or capacity – Available data transfer
- Latency - the measure of time it takes for data to reach its destination across a network.
- Network throughput – Amount of data successfully transferred over the network in a given time
- Network delay and jittering – Any network issue causing packet transfer to be slower than usual
- Data loss and network errors – Packets dropped or lost in transmission and delivery
- Packet Loss refers to the number of data packets that were successfully sent out from one point in a network, but were dropped during data transmission and never reached their destination.
- Network speed, also known as data transfer rate, refers to the speed at which data is transferred between two devices on a network.

NETWORK PERFORMANCE OF TRANSMISSION MEDIA

The performance of transmission media on a network may be measured by three concepts that are

Throughput

The measurement of how many bits pass through a point in once second, is known as throughput. The result shows how fast data passes.

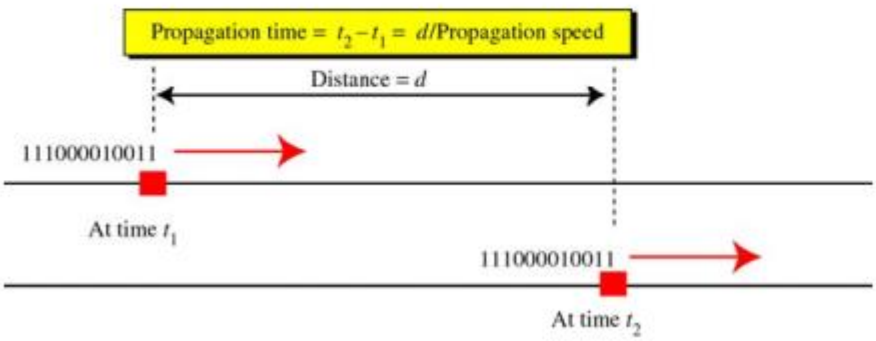


Propagation Time

The time required for a signal or bit to travel from one point to another is Propagation Time. The signal travels from one point of the transmission medium to another.

Calculate Propagation Time using the following formulae

$$\text{Propagation time} = \frac{\text{Distance}}{\text{Propagation speed}}$$



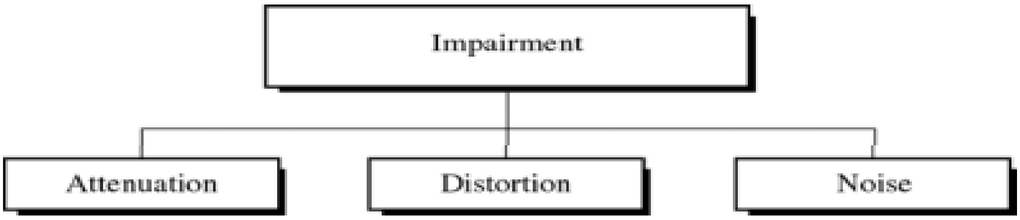
Propagation Speed

The distance a signal or bit travels through a transmission medium in one second. For electromagnetic signals, the propagation medium depends on the medium and frequency of the signal.

Transmission Impairment

Transmission media are not perfect and can cause impairment in the signal sent through the medium. Signals sent at the beginning of the medium may not be the same as the ones received at the end of the medium.

Three types of impairment usually occur: attenuation, distortion, and noise



Attenuation

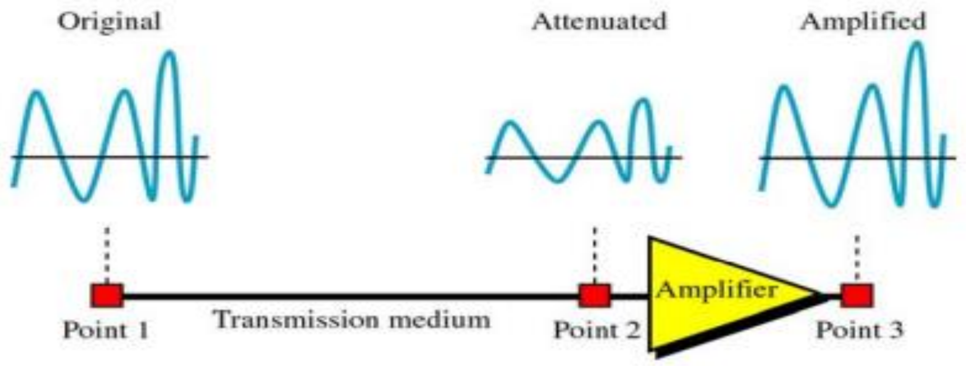
Attenuation means loss of energy. As a signal travels through a medium, it loses some of its energy in order to overcome the resistance of the medium. To compensate for the loss of energy, amplifiers are used to amplify the signal.

Let P1 and P2 be the strengths of a signal at point 1 and 2 (or two signals). The decibel (dB) measures the relative strengths of P1 and P2.

$dB = 10 \log_{10}(P2/P1)$

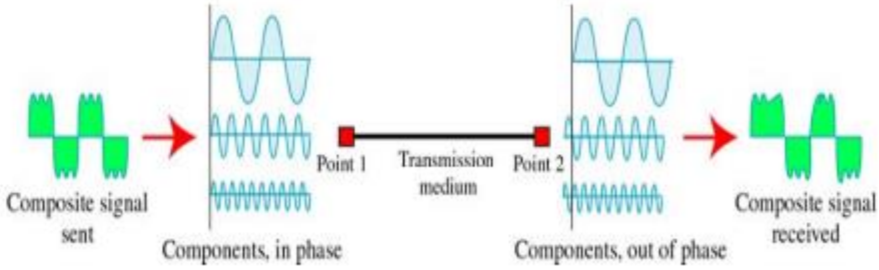
$dB < 0$ (P2 is attenuated relative to P1)

$dB > 0$ (P2 is amplified relative to P1)



Distortion

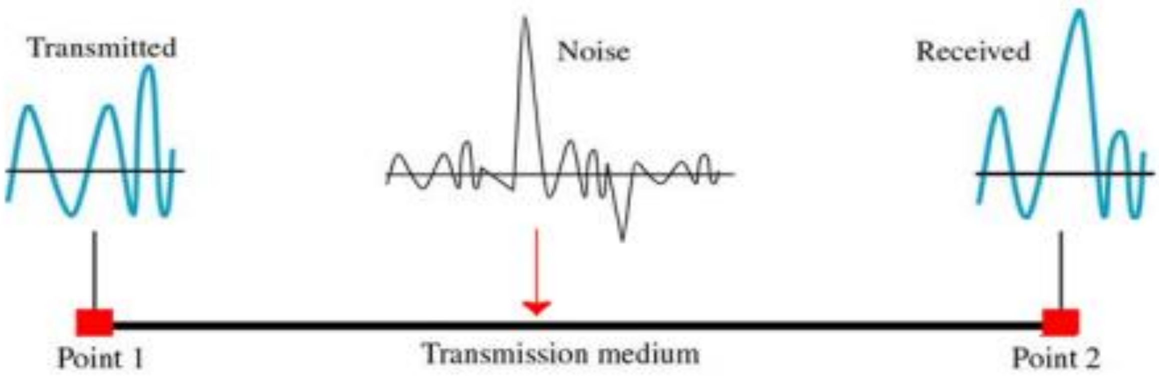
Distortion means the signal has changed its form or shape. Occurs in a composite signal, made of different frequencies each component has its own propagation speed and its own delay in arriving at the final destination.



Noise

Noise can be caused by:

- Thermal noise is the random motion of electrons in a wire that creates an extra signal
- Induced noise comes from sources such as motors and appliances
- Crosstalk is the effect of one wire on the other
- Impulse noise is a spike that come from power lines, lighting



FACTORS IN TRANSMISSION MEDIUM THAT CAUSE DISTORTION OF COMPUTER NETWORK

Network performance can be affected by the transmission media used to transmit data. Different types of media have different characteristics that can impact network performance

TWISTED PAIR CABLE

It comes in two forms: unshielded (UTP) and shielded (STP), Twisted pair cables can experience several performance issues that can impact network performance

Distance

The maximum distance that can be covered by twisted pair cables, both unshielded (UTP) and shielded (STP), depends on several factors such as the cable category, data transmission rate, and environmental factors

Unshielded Twisted Pair (UTP):

i. Category 5e (Cat5e): UTP Cat5e cables can transmit data up to 100 meters (328 feet) at a maximum data rate of 1 Gbps.
ii. Category 6 (Cat6): UTP Cat6 cables can transmit data up to 100 meters (328 feet) at a maximum data rate of 10 Gbps.
iii. Category 6a (Cat6a): UTP Cat6a cables can transmit data up to 100 meters (328 feet) at a maximum data rate of 10 Gbps.

Shielded Twisted Pair (STP):

i. Category 5e (Cat5e): STP Cat5e cables can transmit data up to 100 meters (328 feet) at a maximum data rate of 1 Gbps.
ii. Category 6 (Cat6): STP Cat6 cables can transmit data up to 100 meters (328 feet) at a maximum data rate of 10 Gbps.
iii. Category 6a (Cat6a): STP Cat6a cables can transmit data up to 100 meters (328 feet) at a maximum data rate of 10 Gbps.

Distance is an important factor to consider when using twisted pair cables, as signal attenuation can occur over long distances and impact network performance

Crosstalk:

Crosstalk is interference between wires within a cable. In twisted pair cables, the twisting of the wires reduces crosstalk, but it can still occur if the twists are not tight enough or if the cable is damaged. Crosstalk can cause signal degradation and errors, leading to poor network performance.

EMI:

Electromagnetic interference (EMI) can be caused by nearby electrical devices or other cables. EMI can cause signal distortion or loss, leading to poor network performance. unshielded (UTP) is prone to Electromagnetic interference and noise while shielded (STP) is less prone to Electromagnetic interference

Attenuation:

Attenuation refers to the reduction of signal strength over distance. Twisted pair cables have a limited range, and the signal strength can weaken as the distance increases. Attenuation measures the amount of energy that is lost as the signal arrives at the receiving end of the cabling link. The attenuation measurement quantifies the effect of the resistance the cabling link offers to the transmission of the electrical signals This can cause errors or slow network performance. STP cables have better shielding than UTP cables, but signal attenuation can still occur over long distances.

Impedance mismatches:

Impedance mismatches can occur when the impedance of the cable does not match the impedance of the network interface. This can cause signal reflections and degradation, leading to poor network performance.

Noise:

Noise can be caused by various factors, such as power fluctuations, lightning strikes, or poor cable quality. Noise can cause signal interference and degradation, leading to poor network performance.

Grounding issues:

STP cables require proper grounding to be effective. If the grounding is not done correctly, it can lead to increased signal attenuation and decreased network performance over long distances.

COAXIAL CABLE

Coaxial cable is a type of transmission medium commonly used in computer networks to transmit data. Coaxial cables consist of a copper core surrounded by a dielectric insulator, which is then wrapped in a conductive shield and finally covered with an outer jacket. Here are some network performance issues that can occur with coaxial cables:

Connector issues:

Types of connectors

There are many different types of coaxial cable connectors separated by two styles: male and female connectors. Connector types include the following:

- Bayonet Neill-Concelman (BNC). This connector is used with television, video signal and radio below a frequency of 4 GHz.
- Threaded Neill-Concelman (TNC). This connector is a threaded version of the BNC connector and is used in cellphones. TNC connectors operate up to 12 GHz.
- SubMiniature version A (SMA). This connector is used with cellphones, Wi-Fi antenna systems, microwave systems and radios. SMA connectors operate up to 18 GHz.
- SubMiniature version B (SMB). This connector can be used with telecommunications hardware.

- QMA. QMA connectors are a quick-locking variant of SMA connectors used with industrial and communications hardware.
- Radio Corporation of America (RCA). These connectors are used in audio and video. These are the grouped yellow, white and red cables used with older televisions. RCA connectors are also called A/V jacks.
- F connectors. Also called F-type connectors, these are used in digital and cable televisions. These commonly use RG-6 or RG-59 cables.

Coaxial cables require connectors to attach to network devices, and the quality of these connectors can impact network performance. Poorly made connectors can lead to signal loss, interference, and reduced network performance

Bandwidth limitations:

Coaxial cables have a limited bandwidth, which can impact the speed of data transmission and network performance. The maximum data rate that can be achieved with coaxial cables depends on the quality of the cable and the connectors used.

The bandwidth of a coaxial cable is measured in megahertz (MHz) and is directly related to the maximum data rate that can be achieved. The greater the bandwidth, the higher the maximum data rate that can be transmitted.

- RG-59: This is a common type of coaxial cable used in CCTV and other analog video applications. It has a bandwidth of up to 750 MHz and can transmit data at a maximum rate of 1 Gbps.
- RG-6: This is a higher quality coaxial cable that is commonly used for cable TV, satellite TV, and broadband internet. It has a bandwidth of up to 3 GHz and can transmit data at a maximum rate of 10 Gbps.
- RG-11: This is a heavy-duty coaxial cable used for long cable runs and high-frequency applications. It has a bandwidth of up to 4.5 GHz and can transmit data at a maximum rate of 10 Gbps.

Signal attenuation:

Coaxial cables can suffer from signal attenuation, which occurs when the signal strength decreases as it travels along the cable. This can result in a loss of data, errors in data transmission, and reduced network performance. Signal attenuation can be caused by a variety of factors, including the length of the cable, the quality of the cable, and the type of connectors used

FIBER OPTIC CABLE

Correct specification of fiber optic cabling

The correct fiber optic cabling installed for the speed the network is designed to run. Without this, it'll never reach the speed that desired.

For 10 gigabyte speeds, the maximum cable length you can run ranges from OM1 (33 meters), OM2 (82 meters), OM3 (300 meters), or OM4 (400 meters).

If you ever exceed these distances or pick the wrong type of fiber optic cable, the speed of your network will suffer.

Quality of construction

Poorly terminated cabling with ends that are bent too sharply will either be limited or at a poor range for the transmission to be connected at all. With fusion splicing and correct terminations, standard optical fiber cabling speeds can be guaranteed.

If the cabling becomes dirty, the transmission can also be affected negatively, to the point that it stops working altogether. It's recommended to keep the unused fiber cabling connectors covered at all times, even when not in use, in order to avoid this problem.

Cable tightness

Fiber optic cabling comes with guidelines for band radius and pulling tension installing the main runs. If the cable becomes stretched too tightly, the quality of light down the cable becomes compromised. This is another factor which results in a frustrating poor performance or even complete failure of the cable.

Patching

During the patch process, the leads can become scratched or dirty. Bear in mind that the weakest part of the link will determine the overall quality and performance of the link as a whole. It means a poor patch lead create a poor lead overall. It's recommended for patch leads to be cleaned each time they are re-patched. common network performance issues that can occur with fiber optic cable patching:

1. Insertion Loss: When a fiber optic cable is patched, there is a possibility of signal loss due to the insertion of connectors or splices. This is called insertion loss, and it can result in reduced signal strength and data transmission speed.
2. Reflection: Reflection occurs when the light signal in a fiber optic cable bounces back due to a change in the refractive index of the material. This can happen when there is a mismatch between the connectors or splices, or if the patch cable is dirty or damaged. Reflection can cause signal loss and impair network performance.

Cable damage:

Fiber optic cables can be easily damaged, which can result in signal loss, interference, and reduced network performance. Common causes of cable damage include physical stress, bending, and improper handling.

Light source issues:

The light source used to transmit data over the fiber optic cable can impact network performance. Factors such as light intensity, wavelength stability, and spectral width can all affect the quality of the signal and the network performance. light source problems can impact network performance:

1. Inadequate light source: Fiber optic cables require a light source to transmit data. If the light source is inadequate or not strong enough, the signal can weaken as it travels along the cable. This can result in signal loss, data errors, and reduced network performance.
2. Inconsistent light source: If the light source is not consistent or stable, the signal can fluctuate, leading to data errors and reduced network performance. This can be caused by a variety of factors, including changes in temperature, changes in power supply, or fluctuations in the light source itself.
3. Mismatched light source and cable type: Different types of fiber optic cables require different types of light sources. If the light source and cable type are not matched properly, the signal can be weakened or lost altogether, leading to reduced network performance.

Environmental factors:

Fiber optic cables are susceptible to environmental factors such as temperature, humidity, and vibration. These factors can impact the performance of the cable and lead to signal loss or interference.

Dispersion:

Dispersion refers to the distortion of signals as they travel along the length of the fiber optic cable. There are two main types of dispersion that can occur: chromatic dispersion and modal dispersion.

1. Chromatic dispersion: Chromatic dispersion occurs when different wavelengths of light travel at different speeds through the fiber optic cable. This can lead to a broadening of the pulse of light, which can cause errors in data transmission and decreased network performance. Chromatic dispersion is caused by imperfections in the fiber optic cable and can be mitigated by using high-quality cables and connectors.
2. Modal dispersion: Modal dispersion occurs when the signal is transmitted through multiple paths or modes within the fiber optic cable. This can cause the signal to arrive at the receiving end at different times, leading to errors in data transmission and

decreased network performance. Modal dispersion is caused by imperfections in the cable, such as uneven core diameter or non-uniform refractive index.

Both chromatic and modal dispersion can impact the maximum data rate that can be transmitted over the fiber optic cable. As the distance between the transmitting and receiving devices increases, dispersion becomes more significant, limiting the maximum data rate that can be achieved.

To mitigate dispersion, fiber optic cables can be designed with a graded index, which means that the refractive index of the core gradually decreases towards the edges of the cable. This can help reduce modal dispersion. Additionally, dispersion compensators can be used to correct for chromatic dispersion, but these can add additional cost and complexity to the network.

UNGUIDED MEDIUM OR WIRELESS

Number of devices on the network:

Each connected device requires bandwidth to be able to communicate. The bandwidth of the medium is shared between each connected device. If many devices are connected, the bandwidth allocated to each device would drop, thereby reducing the rate at which data can be sent to any particular device1.

Bandwidth of the transmission medium:

Wireless networks have a limited bandwidth compared to wired networks, which can cause network congestion and slow network performance. To address this issue, it's important to prioritize traffic and implement Quality of Service (QoS) mechanisms to ensure that critical traffic is given priority over less important traffic.

Network latency:

Network latency is a measure of how long it takes a message to travel from one device to another across a network. A network with low latency experiences few delays in transmission, whereas a high latency network experiences many delays1.

Interference:

Wireless networks can experience interference from other wireless devices or networks operating on the same frequency range. This can cause signal degradation and slow network performance. To address this issue, it's important to select the right frequency range and channel for the wireless network and avoid using channels that are already congested.

Range limitations:

Wireless signals can only travel a certain distance before they become weak or lose connectivity. This can cause dead zones in the network where devices cannot connect to the network or experience slow network performance. To address this issue, it's important to deploy wireless access points strategically to ensure that there is adequate coverage and signal strength throughout the network.

To address range limitations in wireless networks, there are several strategies that can be employed:

- Wireless access points strategically: Wireless access points should be deployed in locations that provide the best coverage and signal strength throughout the network. This requires a site survey to identify potential sources of interference and obstacles that can affect signal strength and coverage.
- Transmitter power: Increasing the power output of the wireless transmitter can extend the range of the wireless signal. However, increasing power output should be done carefully, as it can also increase the risk of interference and violate regulatory requirements.
- High-gain antennas: High-gain antennas can focus the wireless signal in a specific direction and increase the range of the signal. However, the use of high-gain antennas also requires careful planning and coordination to ensure that the signal is not blocked by obstacles or cause interference with other wireless networks.

- Wireless repeaters: Wireless repeaters can extend the range of the wireless signal by amplifying and retransmitting the signal. However, the use of wireless repeaters also increases the risk of interference and requires careful placement and configuration to avoid signal degradation.

Security:

Wireless networks are more vulnerable to security threats such as unauthorized access, eavesdropping, and data theft. To address this issue, it's important to implement strong security measures such as encryption, authentication, and access controls to prevent unauthorized access and protect sensitive data. common security issues that can impact the performance of wireless networks:

- Denial of Service (DoS) attacks: DoS attacks are designed to disrupt the normal operation of the network by flooding it with traffic or by overwhelming network devices with requests. DoS attacks can result in network downtime, slow network performance, and loss of productivity.
- Unauthorized access: Wireless networks can be vulnerable to unauthorized access by attackers who use various techniques such as cracking wireless encryption, exploiting security vulnerabilities, or impersonating authorized devices. Unauthorized access can result in data theft, network disruption, and performance degradation.

Environmental factors:

Wireless signals can be affected by environmental factors such as walls, obstacles, and weather conditions. To address this issue, it's important to conduct a site survey to identify potential sources of interference and obstacles and deploy the wireless network accordingly.

CONCLUSION

The choice of transmission media can have a significant impact on the performance of the computer network, each type of transmission whether it be wired or wireless, has its own set of advantages and disadvantages

Wired transmission media such as coper cables and fiber optic cables are generally more reliable and faster than wireless media. They are also less susceptible to interference and signal degradation. However, they can be more expensive to install and may require more maintenance

Wireless transmission media, such as Wi-Fi and Bluetooth are more flexible and convenient than wired media, allowing or greater mobility and easier network expansion. However, they more prone to interference and signal loss, which can lead to decrease or distortion of the network performance

Ultimately, the choice of transmission media will depend on the specific needs of the network, as well as factors such as cost, reliability and ease of use. Analysis of these factors should be conducted before making a decision on which type of transmission media to use in a computer network

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