**ELEMENTS (COMPONENTS) OF NETWORKING**

A computer network is made up of several standard components, which can be classified into three (3) major categories, namely:

1. Data communication media.
2. Communication devices.
3. Networking software.

**1.Data communication (Transmission) media.**

A ***data communication medium*** is a physical pathway used for carrying data signals & information from one point to another.

Data communication media can be divided into two:

1. Communication using cable (bound media).
2. Wireless communication (unbounded media).

**Communication using cables (bounded media).**

In bounded media, data signals are transmitted from the source to the destination through a cable.

There are 4 major types of bounded transmission media, namely:

1. Two-wire open lines cables.
2. Twisted pair cables.
3. Coaxial cables.
4. Fibre optic cables.

**Two-wire open lines cables.**

Two-wire open lines cables are made up of 2 parallel copper wires separated by a plastic insulator.

Plastic insulator

Wire conductor

The *Plastic insulator* is meant to reduce signal interference called **Crosstalk**. However, the linear nature of the wires allows an electromagnetic field to build around them during heavy data transmission, which may cause interference to the signal.

The wires also capture/pick unwanted environmental frequencies, e.g., radio waves, hence causing ***noise*** in the transmission channel.

Two-wire open lines cables are used in telecommunication network to transmit voice (analogue) signals.

**Twisted pair cables.**

A twisted pair cable is made up of 2 insulated copper wires twisted around each other in a spiral pattern.



The twisting prevents electromagnetic fields from developing around the two wires as they transmit data.

Twisted pair cables can be used to transmit both voice & data signals (i.e., analogue & digital signals).

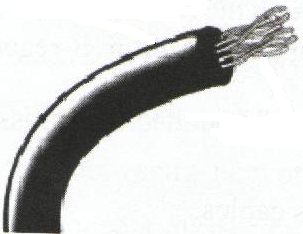
***Types of twisted pair cables.***

The 2 common types of twisted pair cables are:

1. Unshielded twisted pair (UTP).
2. Shielded twisted pair (STP).

**Unshielded twisted pair (UTP) cables.**

UTP cables do not have a shield that prevents electromagnetic interference (also called ‘***Electric noise***’) from the environment.



Twisted pair

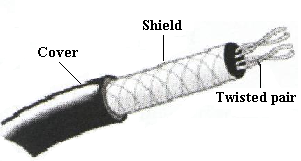
Outer cover

UTP cable is prone to noise & signal interference, and therefore, not suitable for environments that are electrically ‘noisy’.

Noise may come from lightening sparks, radio signal, or radiations from spark plugs in motor vehicles.

**Shielded twisted pair (STP) cables.**

In STP cables, a braided shield is wrapped around the wires to protect them from noise.



Twisted pair cables are grouped into 5 categories according to the type of data transmitted, and the maximum rate of transmission.

|  |  |  |
| --- | --- | --- |
| **Category** | **Speed (max. limit)** | **Suitable for transmitting** |
| 1 | Less than 1 Mbps (i.e., Megabits per second) | Voice |
| 2 | 1 Mbps | Data |
| 3 | 16 Mbps | Data |
| 4 | 20 Mbps | Data |
| 5 | 100 Mbps | Data |

**Advantages of Twisted pair cables.**

1. Can support high data rates (bandwidth) of up to 100 Mbps.
2. Telephone systems use UTP, which is present in most buildings. Therefore, it is easier to setup network media because; connection is readily available.
3. Installation equipment is cheap & readily available.
4. It is cheap because; of mass production for telephone use.

**Disadvantages of Twisted pair cables.**

1. They suffer from high attenuation. Therefore, for every cable length of 90m, a “**Repeater**” is needed to amplify (restore) the signal.
2. It is sensitive to electromagnetic interference & eavesdropping.
3. It has low data transmission rates as compared to other cables.

**Coaxial cables.**

A Coaxial cable resembles the cable that is used to connect television antenna to a television set.

The cable has;

1. A central *copper core* (which is either solid or stranded wires).

The diameter of the centre core determines the attenuation rate. If the core is thin, then the attenuation rate will be higher.

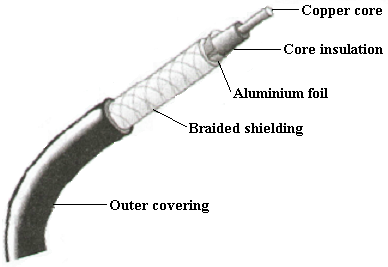
1. An *insulator* (a dielectric material) surrounding the copper core.
2. A hollow *braid* (mesh conductor) surrounding the insulator. The braid is made of copper or aluminium, and serves as the ground for the carrier wire.
3. A *shield* which covers the braid making the core more resistant to electromagnetic interference.

The braid together with the insulator & the foil shield protects the carrier wire from Radio Frequency Interference (RFI) and Electromagnetic Interference (EMI).

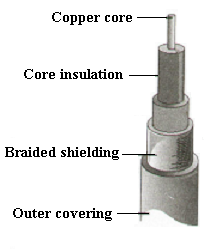
Coaxial cables have bandwidths of up to *1 Gbps* (Gigabits per second). Hence, they can be used to link/connect different networks between buildings, and route trunk calls in telecommunication companies.

***The Two types of coaxial cables.***

1. *Thin coaxial cable (Thinnet)*: - it has 1 dielectric insulator around the core.



1. *Thick coaxial cable (Thicknet)*: - it has 2 dielectric insulators around the core, and is thicker than the thinnet.



**Advantages of coaxial cables.**

1. They are very stable even under high loads.
2. They have a large bandwidth (up to 1Gbps) compared to twisted pair cables.
3. They can carry voice, data and video signals simultaneously.
4. They are more resistant to radio and electromagnetic interference than twisted pair cables.

**Disadvantages of coaxial cables.**

1. Thick coaxial cable is hard to work with.
2. They are relatively expensive to buy & install compared to twisted pair cables.

**Fibre optic cables.**

A fibre optic cable uses light to transmit data signals from one point to another on the network.

A ***Light Emitting Diode*** (***LED***) is used at the source/transmitter (sending computer) to convert electrical signals to light signals which are then send along the cable. At the receiving computer, a ***photosensitive*** device is then used to convert the light signals back to electric signals that can be processed by the computer.

A fibre optic cable is made up of;

1. **The Core**.

This is the central part of the cable, and is made of a hollow transparent plastic or glass.

1. **Cladding**.

This is a single protective layer surrounding the core.

The Cladding is able to bend light rays, (i.e., when light tries to travel from the core to the cladding, it is redirected back to the core).

1. **Buffer**.

It surrounds the cladding. Its main function is to strengthen the cable.

1. **The Jacket**.

It is the outer covering of the cable.

**Light transmission along a fibre optic cable.**

The light signal travels along the core through a process referred to as ***Total internal reflection***.

The process that causes total internal reflection is called **Refraction**. *Refraction* is the bending of light when it crosses the boundary of two mediums that have different densities.

Therefore, when light signal is inserted into the cable, it tries to cross from the core to the cladding. The light is bent back into the core, hence spreads along the length of the cable.

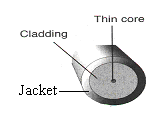
Light rays

Core Cladding

***Types of fibre optic cables.***

1. **Single mode fibre optic cable**.

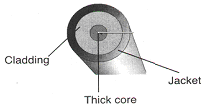
The single mode fibre has a very narrow centre core. This implies that, the light in the cable can take only one path through it.



* + It has a very low attenuation rate, and is preferred for long distance transmission.
  + It has a very high bandwidth of 50 Gigabits per second.
  + It is very expensive, and requires very careful handling during installation.

1. **Multimode fibre optic cable.**

A multimode fibre has a thicker centre core than the single mode fibre.



* + It allows several light signals (rays) to be sent through the cable at the same time. Hence, there are high chances of the signal being distorted.
  + It has a high attenuation rate, and is usually used for shorter distance transmission.

**Advantages of fibre optic cable.**

1. It is immune to electromagnetic interference, and eavesdropping.
2. It is fast and supports high bandwidth.
3. It has low attenuation; hence, a long distance can be covered.
4. It does not generate electrical signals; hence can be used in dangerous (highly flammable) places.
5. It is smaller & lighter than copper cables; hence, suitable for situations where space is limited.

**Disadvantages of fibre optic cable.**

1. Requires expensive connectivity devices and media.
2. Installation is difficult because the cable must be handled carefully.
3. It is relatively complex to configure.
4. A broken fibre optic cable is difficult & expensive to repair.

**Review questions.**

1. Define the term Transmission media.
2. **(a).** Give two advantages of coaxial cables.

**(b).** Explain the importance of the wire braid in coaxial cable.

1. Distinguish between Thinnet and Thicknet coaxial cables.
2. Define the term Pitch as used in twisted pair cabling.
3. **(a).** Give two advantages of fibre optic media.

**(b).** Differentiate between single mode and multimode fibre optic cables.

**Wireless communication (unbounded media)**

*Wireless* (*unbounded*) *media* is a type of media that is used to transmit data from one point to another *without using physical connections*.

In this case, a transmitting *antenna* & a receiver *aerial* are used to facilitate the communication.

Examples of wireless communication media include:

1. Microwaves.
2. Radiowaves.
3. Infrared transmission.

All these waves use different frequencies of the electromagnetic spectrum, and travel at the speed of light.

Below is a diagrammatic representation of the electromagnetic spectrum

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Radiowaves | | | Microwaves | Infra-red (IR) | Visible light | Ultra-violet (UV) | X-Rays | Gamma rays |
| High Frequency  (HF) | Very High  Frequency (VHF) | Ultra-High  Frequency (UHF) |
| 106 Hz | 107 Hz | 108 Hz | 1010 Hz | 1013 Hz | 1015 Hz | 1016 Hz | 1020 Hz | 1022 Hz |

**Microwave transmission**

Microwave frequencies have a small wavelength, and can easily release their energy in water as heat. This is why they are used in making domestic kitchen appliances, e.g., microwave ovens.

In networking, microwaves are suitable for *point-to-point* transmissions, whereby a signal is directed through a focused beam from the transmitter to the receiver station.

Line of sight

**Satellite communication**

A Satellite is a microwave relay station. The microwave earth stations have parabolic dishes with an antenna fixed on them in order to focus a narrow beam towards the satellite in space.

A satellite transmission system has 3 main components:

1. ***Transmitter earth station*** - it sets up an *uplink* to the satellite in order to transmit data.
2. A ***Satellite*** that is somewhere in an orbit. It receives, amplifies, and retransmits the signal to a receiving earth station through a *downlink* frequency.

The downlink & the uplink frequency are usually different. This is to prevent the downlink signal from interfering with the uplink signal.

1. ***Receiving earth station*** - receives the signal sent by the satellite on the other side of the globe.

Satellite in space

Uplink Downlink

Transmitter Receiving

earth station earth station

A communication satellite is usually launched into space about 36,000 km above the earth in such a manner that its speed is almost equal to the rotation speed of the earth. This makes the satellite appear as if it is stationary in space. Such types of satellites are called ***geostationary*** satellites.

**Advantages of using satellites**

1. A satellite is convenient because; it provides a large constant line of sight to earth stations. This means that, there is no need to keep on moving the parabolic dish so as to track the line of sight.
2. The satellite transmits the signal to many recipient earth stations. This is because; the transmitted signal spreads out in all directions to form a *Point to Multipoint* transmission.

**Very Small Aperture Terminal** (**VSAT**)

A *VSAT* is a very small satellite dish used both in data, radio, and TV communication.

It can be set up at home or in a small business. It enables direct access to satellite communication instead of having to go through state-owned or licensed satellite gateways.

The dish has an antenna that receives the satellite signals. The signals are decoded using a *decoder* which is plugged directly to a television set or a computer.

**Radio communication**

Radio waves are used in radio and television broadcasts.

Radio waves travel just like surface water waves, i.e., they start from a central point and spread outwards in all directions.

As they travel outwards, their energy spreads outwards over the covered area. The waves are radiated into the atmosphere by a radio frequency antenna at constant velocity.

The figure below shows a typical radio waves link between two separate geographical locations.

Path

Transmitting Receiving

antenna antenna

Power supply

TRANSMITTER RECEIVER

Fig.: A typical radio transmitter and receiver link

Radio waves can be of:

* High frequency (HF).
* Very high frequency (VHF).
* Ultra-high frequency (UHF).

**High frequency (HF) radio waves**

The *High frequency* radio wave signal is transmitted by directing it to the *ionosphere* of the earth. The ionosphere reflects it back to the earth’s surface, and the receiver then picks the signal.

*Disadvantage of HF communication*

* The signal can be intercepted by unauthorized parties.

**Very High frequency (VHF) radio waves**

They are transmitted along the earth’s surface. However, since the earth is somehow curved, the signal tends to attenuate at the horizons of mountains and buildings. This means that, *repeater stations* have to be built on raised areas in order to receive, amplify, and propagate the signal from one area to another.

**Note**. The range of VHF is limited, however, it is preferred to HF because; it is possible to make a VHF wave follow a narrower & more direct path to the receiver.

**Ultra-High frequency (UHF) radio waves**

The UHF radiowaves use the *line of sight principle* used by the VHF waves. This means that, there should be no barrier between the sending & the receiving aerial. However, they require smaller aerials.

*For example;*

The Television aerial for VHF is bigger than the one for UHF radio waves. This is because; UHF radio waves can be made to follow a narrower & a more direct path to the receiver than VHF radio waves.

***The Bluetooth technology***

This is a worldwide and short range radio transmission technology that allows all personal, hand-held devices to be able to communicate with each other through wireless technology.

It enables people to use hand-held communication devices such as mobile phones & Personal Digital Assistants (PDA’s) to access the Internet.

The main component in Bluetooth is a small *low power* two-way radio transceiver, which can be inserted in small devices.

Bluetooth enabled devices use a network called the *Wireless personal area network* (*WPAN*) or *piconet*.

**Infrared transmission**

Communication through infrared waves (signals) is achieved by having infrared transmitters & receivers (*transceivers*) within a line of sight in the same room. This is because; infrared signals cannot penetrate obstacles like walls and ceilings. However, the signal can be reflected off these surfaces until they reach their destination.

*For example;*

Most mobile phones have an infrared transceiver. Once activated, two people in the same room can send messages to each other on their mobile phones without going through the mobile service provider; hence avoid being charged.

In computer networking environment, infrared technology can be used to connect devices in the same room to each other without the need for cables, e.g., a computer and a printer. However, the computer’s infrared transceiver must maintain a line of sight with the one for the printer.

**Advantages of wireless communication.**

1. Wireless medium is flexible in operation, i.e., devices can be moved around without losing access to the network.
2. Wireless networks can span large geographical areas easily.
3. Wireless communication can take place via satellite even in very remote areas that do not have high cost physical infrastructure like telephone lines.

**Disadvantages of wireless communication.**

1. The initial cost is very high.
2. It is relatively difficult to establish or configure.

**Review questions.**

1. Distinguish between radio and microwave transmission.
2. Describe an electromagnetic spectrum.
3. State two advantages of satellite communication.
4. Give one application area of Infrared transmission.
5. Describe the VSAT technology.
6. Explain the concept of a geostationary satellite.
7. Explain the *line of sight principle* in wireless communication.