DCCN - 1

Physical Layer

In the seven-layer OSI model of computer networking, the physical layer or layer 1 is the first and lowest layer. The physical layer defines the means of transmitting raw bits over a physical data link connecting network nodes. The bitstream may be grouped into code words or symbols and converted to a physical signal that is transmitted over a transmission medium. The physical layer provides an electrical, mechanical, and procedural interface to the transmission medium. The shapes and properties of the electrical connectors, the frequencies to broadcast on, the line code to use and similar low-level parameters, are specified by the physical layer.[1]

It is a fundamental layer underlying the higher level functions in a network, and can be implemented through a great number of different hardware technologies with widely varying characteristics. Within the semantics of the OSI model, the physical layer translates logical communications requests from the data link layer into hardware-specific operations to cause transmission or reception of electronic (or other) signals. The physical layer supports higher layers responsible for generation of logical data packets.[1]

Guided/ Wired Transmission Media

In Guided Transmission media, signals being transmitted are directed and confined in a narrow pathway by using physical links.

General features:

- High Speed
- Secure
- Used for comparatively short distances

The following are major types of Guided Media:

Twisted Pair Cable:

It consists of 2 separately insulated conductor wires wound about each other. Generally, several such pairs are bundled together in a protective sheath. They are the most widely used Transmission Media. Twisted Pair is of two types:

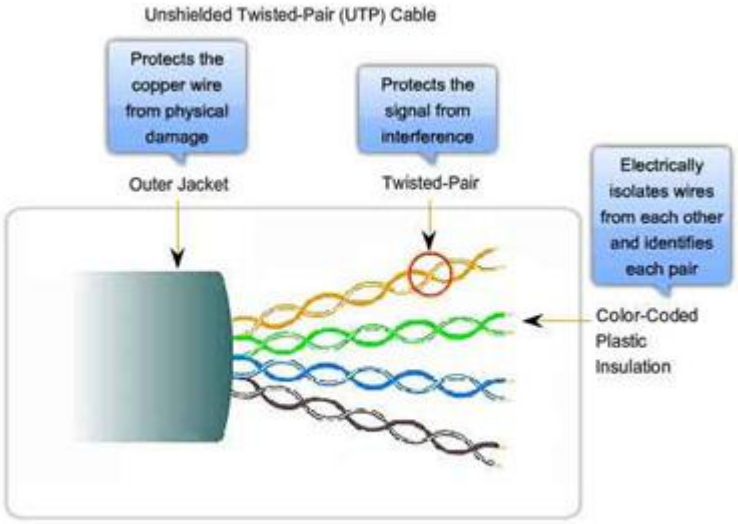
Unshielded Twisted Pair (UTP):

This type of cable has the ability to block interference and does not depend on a physical shield for this purpose. It is used for telephonic applications.

Since, the unshielded twisted pair is one that has a small diameter and is thin, it can be laid down for large distances.

- The following summarizes the features of UTP cable:
- Speed and throughput—10 to 1000 Mbps
- Average cost per node—Least expensive
- Media and connector size—Small
- Maximum cable length—100 m (short) [2]

UTP cables are mostly used for LAN networks. They can be used for voice, low-speed data, high-speed data, audio and paging systems, and building automation and control systems. UTP cable can be used in both the horizontal and backbone cabling subsystems.



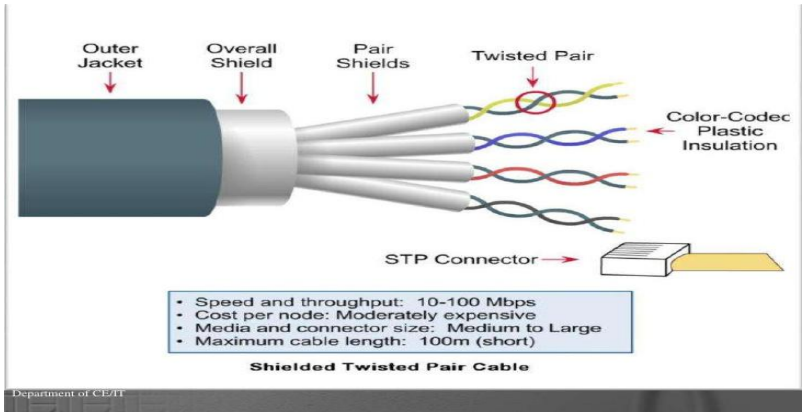
Shielded Twisted Pair (STP):

Shielded twisted pair (STP) cable include two individual wires covered with a foil shielding, which prevents electromagnetic interference, thereby transporting data faster. STP is similar to unshielded twisted pair (UTP); however, it contains an extra foil wrapping or copper braid jacket to help shield the cable signals from interference. STP cables are costlier when compared to UTP, but has the advantage of being capable of supporting higher transmission rates across longer distances.

The shielding reduces EMI in STPs

- The following summarizes the features of STP cable:
- Speed and throughput—10 to 100 Mbps
- Average cost per node—Moderately expensive
- Media and connector size—Medium to large
- Maximum cable length—100 m (short) [2]

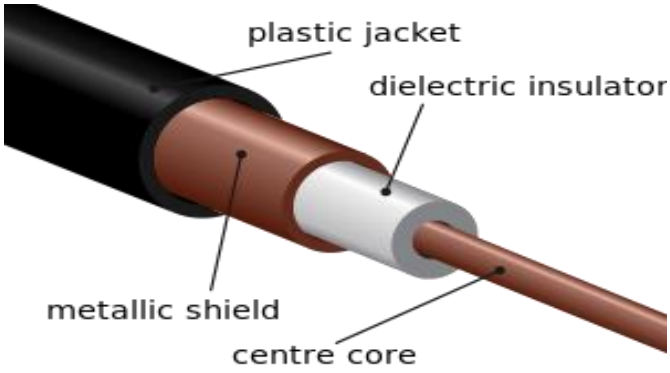
STP cabling often is used in Ethernet networks, especially fast data rate Ethernets.



Coaxial Cable:

Coaxial cable consists of a hollow outer cylindrical conductor that surrounds a single inner wire made of two conducting elements. One of these elements, located in the center of the cable, is a copper conductor. Surrounding the copper conductor is a layer of flexible insulation. Over this insulating material is a woven copper braid or metallic foil that acts both as the second wire in the circuit and as a shield for the inner conductor. This second layer, or shield, can help reduce the amount of outside interference. Covering this shield is the cable jacket[3]

- The following summarizes the features of coaxial cables:
- Speed and throughput—10 to 100 Mbps
- Average cost per node—Inexpensive
- Media and connector size—Medium
- Maximum cable length—500 m (medium)[2]



Coaxial cable is a type of transmission line, used to carry high-frequency electrical signals with low losses. It is used in such applications as telephone trunklines, broadband internet networking cables, high-speed computer data busses, cable television signals, and connecting radio transmitters and receivers to their antennas. It differs from other shielded cables because the dimensions of the cable and connectors are controlled to give a precise, constant conductor spacing, which is needed for it to function efficiently as a transmission line. It is used in ethernet systems.

Fiber Optic Cable:

A fiber-optic cable, also known as an optical-fiber cable, is an assembly similar to an electrical cable, but containing one or more optical fibers that are used to carry light. The optical fiber elements are

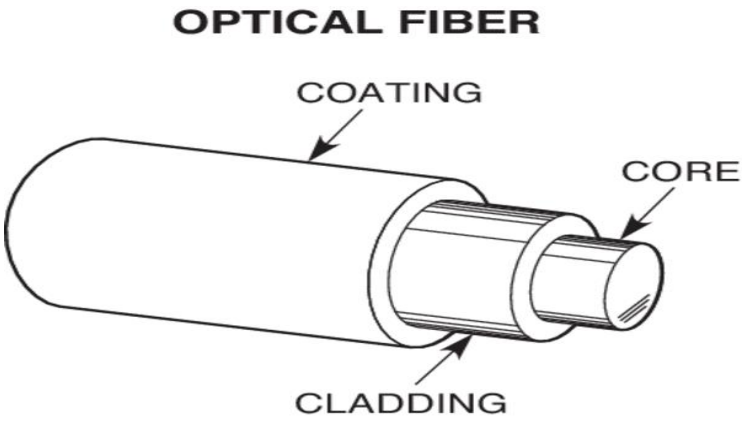
typically individually coated with plastic layers and contained in a protective tube suitable for the environment where the cable will be deployed.

Optical fiber consists of a core and a cladding layer, selected for total internal reflection due to the difference in the refractive index between the two.

Optical fibers are very strong, but the strength is drastically reduced by unavoidable microscopic surface flaws inherent in the manufacturing process.

The following summarizes the features of fiber optic cables:

- They have practically unlimited information
- They have high carrying capacity (very broad bandwidth, THz or Tbits/s)
- They have very low transmission losses (<0.2dB/km, cf1dB/km microwave, 10db/km twisted copper pair)
- They do not dissipate heat
- They are immune to cross-talk and electromagnetic interference [3]



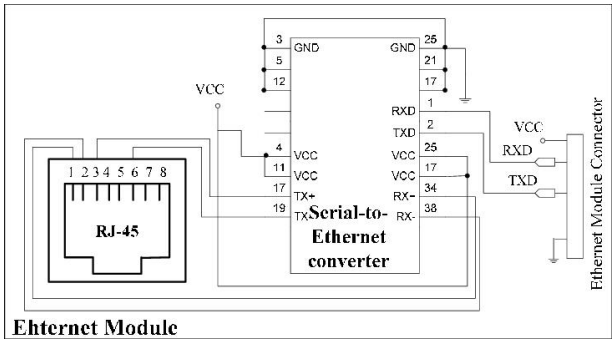
Technologies :

Ethernet :

Ethernet is a family of computer networking technologies commonly used in local area networks (LAN), metropolitan area networks (MAN) and wide area networks (WAN).

Systems communicating over Ethernet divide a stream of data into shorter pieces called frames. Each frame contains source and destination addresses, and error-checking data so that damaged frames can be detected and discarded; most often, higher-layer protocols trigger retransmission of lost frames. As per the OSI model, Ethernet provides services up to and including the data link layer.

Ethernet is widely used in homes and industry, and interworks well with Wi-Fi. The Internet Protocol is commonly carried over Ethernet and so it is considered one of the key technologies that make up the Internet. [4]

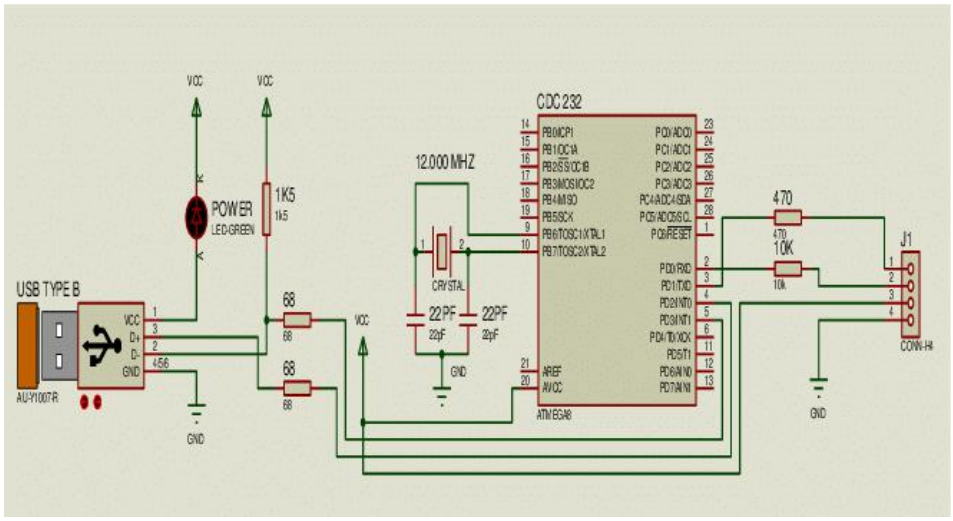


USB :

Short for universal serial bus, USB is a plug and play interface that allows a computer to communicate with peripheral and other devices. USB-connected devices cover a broad range; anything from keyboards and mice, to music players and flash drives.

USB Version 1 allowed for two speeds: 1.5 Mb/s (megabits per second) and 12 Mb/s, which work well for slow I/O devices. USB Version 2 allows up to 480 Mb/s and is backward compatible with slower USB devices. The first USB version 3 (USB 3.0 or SuperSpeed USB) was released in 2008, and allowed for a speed of 500 Mb/s. In 2013 and 2017, two new USB version 3 were released: USB 3.1 and USB 3.2, which allowed for 1.21 Gb/s and 2.42 Gb/s, respectively.

USB can be used to set up PANs.
USB was designed to standardize the connection of peripherals to personal computers, both to communicate with and to supply electric power. It has largely replaced interfaces such as serial ports and parallel ports, and has become commonplace on a wide range of devices.



Unguided/ Wireless Media

It is also referred to as Wireless or Unbounded transmission media.No physical medium is required for the transmission of electromagnetic signals.

Features:

- Signal is broadcasted through air
- Less Secure
- Used for larger distances

Bluetooth :

Bluetooth is a wireless technology standard used for exchanging data between fixed and mobile devices over short distances using short-wavelength UHF radio waves in the industrial, scientific and medical radio bands, from 2.402 GHz to 2.480 GHz, and building personal area networks (PANs). It was originally conceived as a wireless alternative to RS-232 data cables.

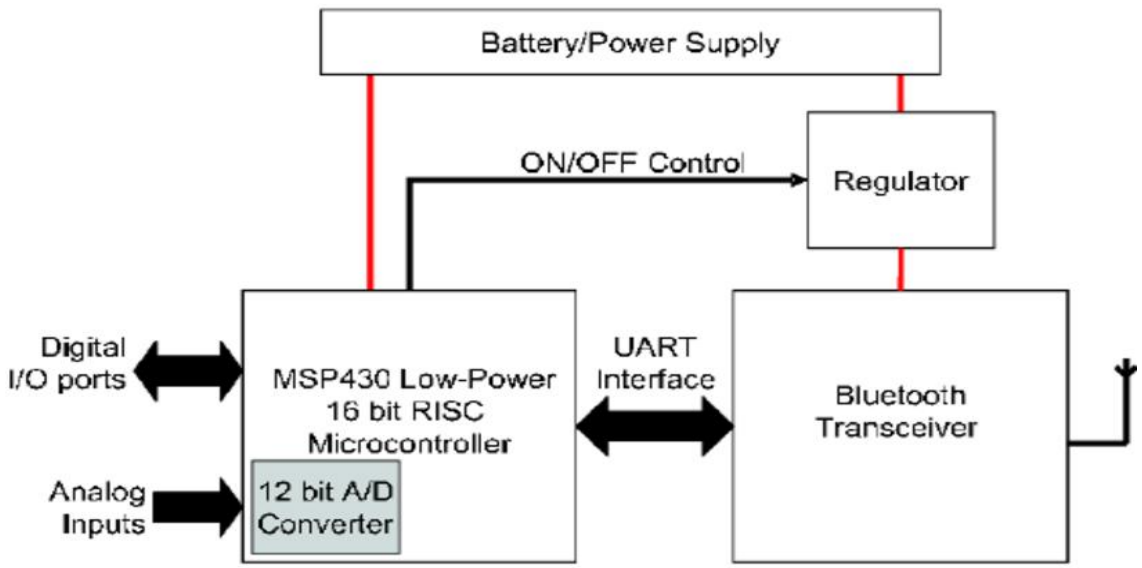
Bluetooth is a packet-based protocol with a master/slave architecture. One master may communicate with up to seven slaves in a piconet. All devices within a given piconet use the clock provided by the master as the base for packet exchange.

Bluetooth is a standard wire-replacement communications protocol primarily designed for low power consumption, with a short range based on low-cost transceiver microchips in each device. Because the devices use a radio (broadcast) communications system, they do not have to be in visual line of sight of each other. [6]

The format originally chosen for Bluetooth in version 1 was Gaussian frequency shift keying, GFSK, however with the requirement for higher data rates two forms of phase shift keying were introduced for Bluetooth 2 to provide the Enhanced Data Rate, EDR capability.[7]

Bluetooth-enabled consumer electronics such as phones, cameras, televisions, speakers and headphones simplify data sharing between devices. A Bluetooth mobile phone, for example, can wirelessly connect to a headset to make hands-free calling easier or can send pictures to another phone or computer. [6]

Bluetooth can be used to setup PANs.



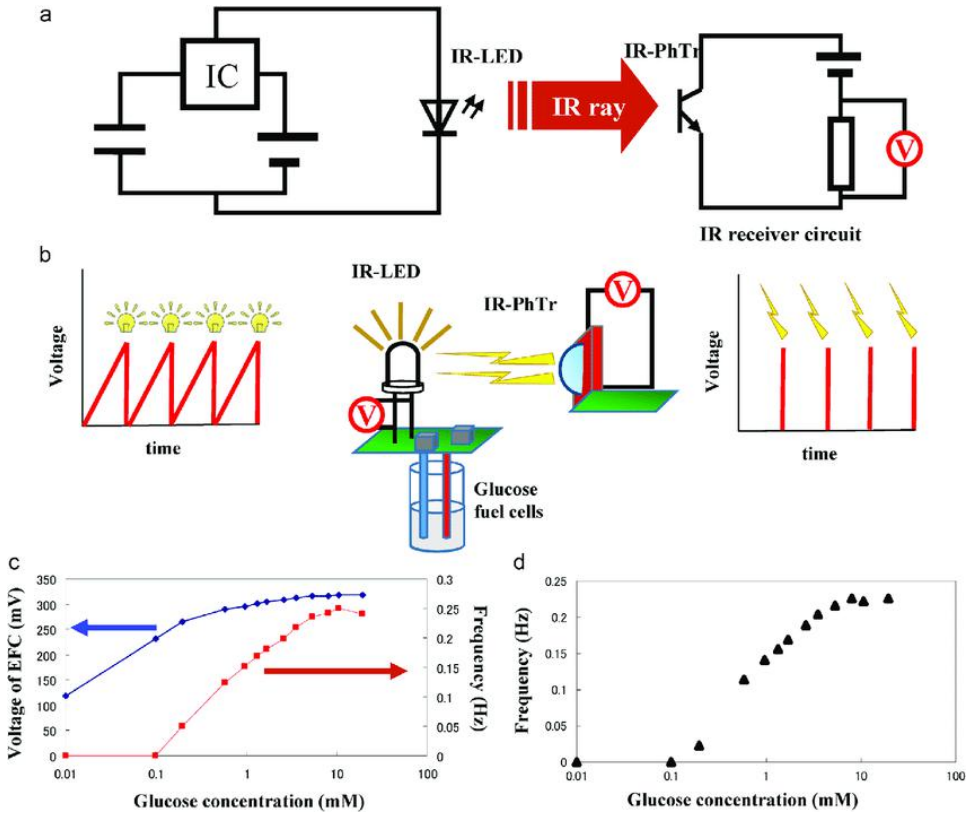
Infrared (IR Wireless) :

IR wireless is the use of wireless technology in devices or systems that convey data through infrared (IR) radiation. Infrared is electromagnetic energy at a wavelength or wavelengths somewhat longer than those of red light. The shortest-wavelength IR borders visible red in the electromagnetic radiation spectrum;the longest-wavelength IR borders radio waves.

IR wireless technology is used in intrusion detectors; home-entertainment control units; robot control systems; medium-range, line-of-sight laser communications; cordless microphones, headsets, modems, and printers and other peripherals.

Unlike radio-frequency (RF) wireless links, IR wireless cannot passthrough walls. Therefore, IR communications or control is generally not possible between different rooms in a house, or between different houses in a neighborhood (unless they have facing windows). This might seem like a disadvantage, but IR wireless is more private than RF wireless. Some IR wireless schemes offer a level of securitycomparable to that of hard-wired systems. It is difficult, for example, to eavesdrop on a well-engineered, line-of-sight, IR laser communications link. [8]

Infrared Technology can be used for setting up PAN networks.



NFC(Near Field Communication):

Near-Field-Communication (NFC) is a set of communication protocols for communication between two electronic devices over a distance of 4 cm or less. NFC offers a low-speed connection with simple setup that can be used to bootstrap more-capable wireless connections. NFC devices can act as

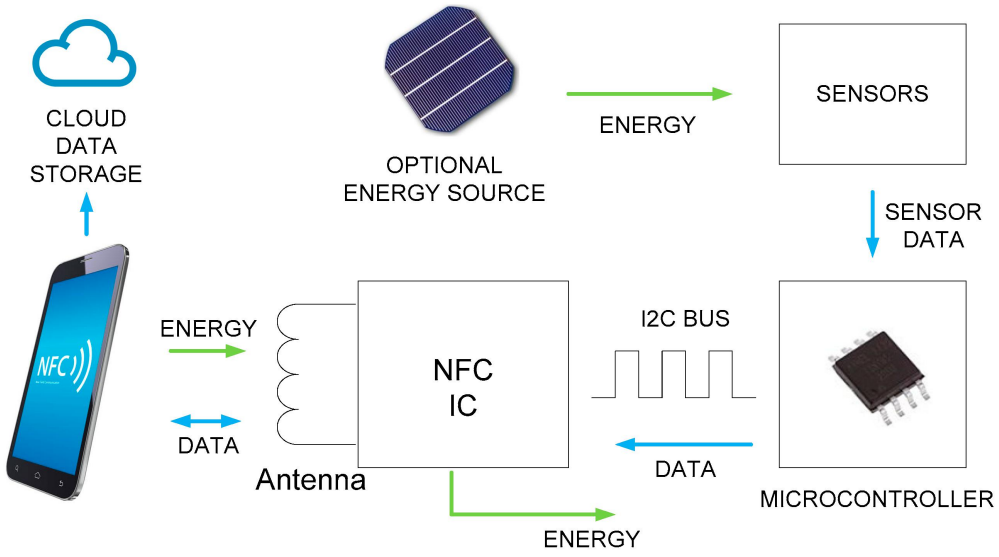
electronic identity documents and keycards.[2] They are used in contactless payment systems and allow mobile payment replacing or supplementing systems such as credit cards and electronic ticket smart cards.

NFC employs two different coding systems on the RF signal to transfer data. In most cases a level of 10% modulation is used, with a Manchester coding format. However for an active device transmitting data at 106 kbps, a modified Miller coding scheme is used with 100% modulation.

Every active NFC device can work in one or more of three modes:

- NFC card emulation : Enables NFC-enabled devices such as smartphones to act like smart cards, allowing users to perform transactions such as payment or ticketing.
- NFC reader/writer : Enables NFC-enabled devices to read information stored on inexpensive NFC tags embedded in labels or smart posters.
- NFC peer-to-peer : Enables two NFC-enabled devices to communicate with each other to exchange information in an ad hoc fashion. [9]

NFCs are used to set up PANs.



WiFi (Wireless Fidelity):

Wi-Fi is a family of wireless network protocols, based on the IEEE 802.11 family of standards, which are commonly used for local area networking of devices and Internet access.Wi-Fi uses multiple parts of the IEEE 802 protocol family and is designed to interwork seamlessly with its wired sibling Ethernet. Compatible devices can network through wireless access points to each other as well as to wired devices and the Internet. The different versions of Wi-Fi are specified by various IEEE 802.11 protocol standards, with the different radio technologies determining radio bands, and the maximum ranges, and speeds that may be achieved. Wi-Fi most commonly uses the 2.4 gigahertz (120 mm) UHF and 5 gigahertz (60 mm) SHF ISM radio bands; these bands are subdivided into multiple channels. Channels can be shared between networks but only one transmitter can locally transmit on a channel at any moment in time.

An access point often has a range of about 20 metres (66 feet) indoors while some modern access points claim up to a 150-metre (490-foot) range outdoors. Coverage can be as small as a single room with walls that block radio waves, or as large as many square kilometres using many overlapping access points with roaming permitted between them.

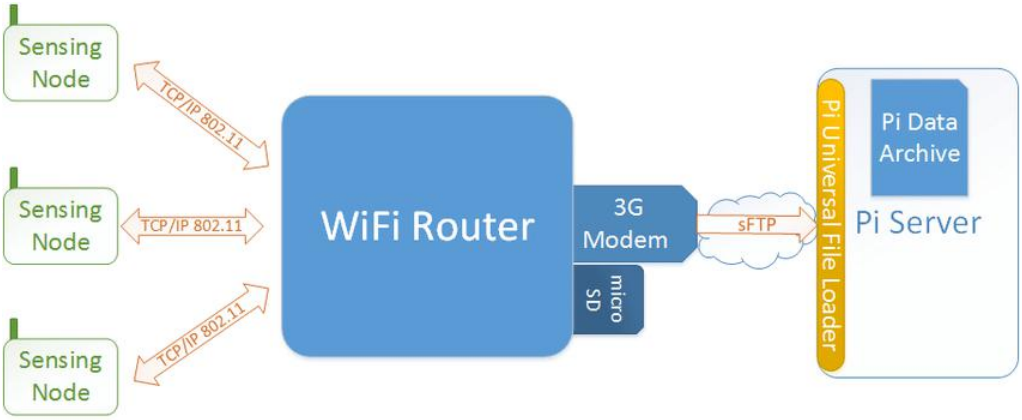
Versions of Wi-Fi, running on suitable hardware, can achieve speeds of over 1 Gbit/s. [10]

WiFi systems use two primary radio transmission techniques.

- 802.11b (<=11 Mbps) − The 802.11b radio link uses a direct sequence spread spectrum technique called complementary coded keying (CCK). The bit stream is processed with a special coding and then modulated using Quadrature Phase Shift Keying (QPSK).

- 802.11a and g (<=54 Mbps) − The 802.11a and g systems use 64-channel orthogonal frequency division multiplexing (OFDM). In an OFDM modulation system, the available radio band is divided into a number of sub-channels and some of the bits are sent on each. The transmitter encodes the bit streams on the 64 subcarriers using Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK), or one of two levels of Quadrature Amplitude Modulation (16, or 64-QAM). Some of the transmitted information is redundant, so the receiver does not have to receive all of the sub-carriers to reconstruct the information. [11]

WiFi has applications in LAN(WLAN) and can also be used to setup PAN.



Cellular Network:

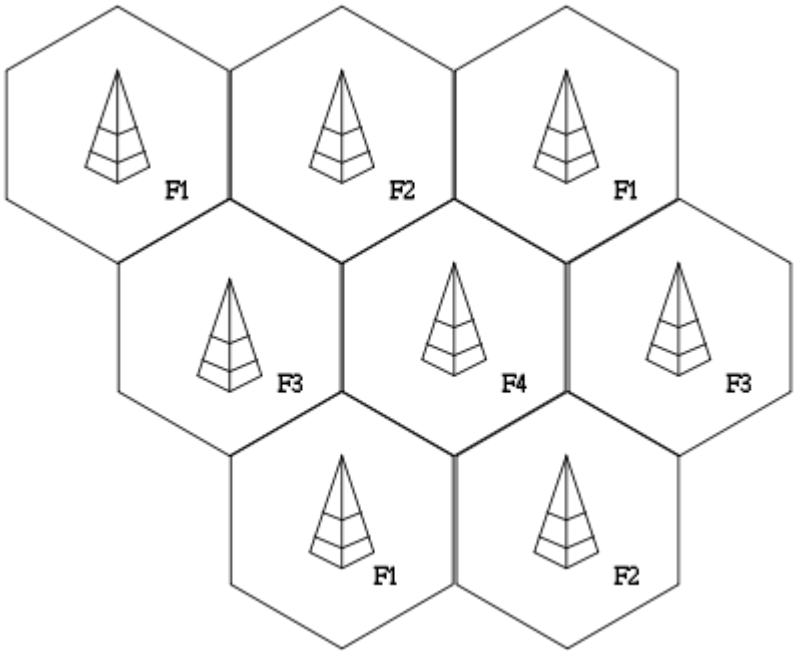
A cellular network or mobile network is a communication network where the last link is wireless. The network is distributed over land areas called "cells", each served by at least one fixed-location transceiver, but more normally, three cell sites or base transceiver stations. These base stations provide the cell with the network coverage which can be used for transmission of voice, data, and other types of content. A cell typically uses a different set of frequencies from neighbouring cells, to avoid interference and provide guaranteed service quality within each cell.

Cellular networks offer a number of desirable features:

- More capacity than a single large transmitter, since the same frequency can be used for multiple links as long as they are in different cells
- Mobile devices use less power than with a single transmitter or satellite since the cell towers are closer
- Larger coverage area than a single terrestrial transmitter, since additional cell towers can be added indefinitely and are not limited by the horizon. [14]

OFDM is the modulation scheme, widely employed in the current 4G LTE systems.

Cellular Networks are used in communication and are used to provide internet.



LTE(Long-Term Evolution) (Type of Cellular Network):

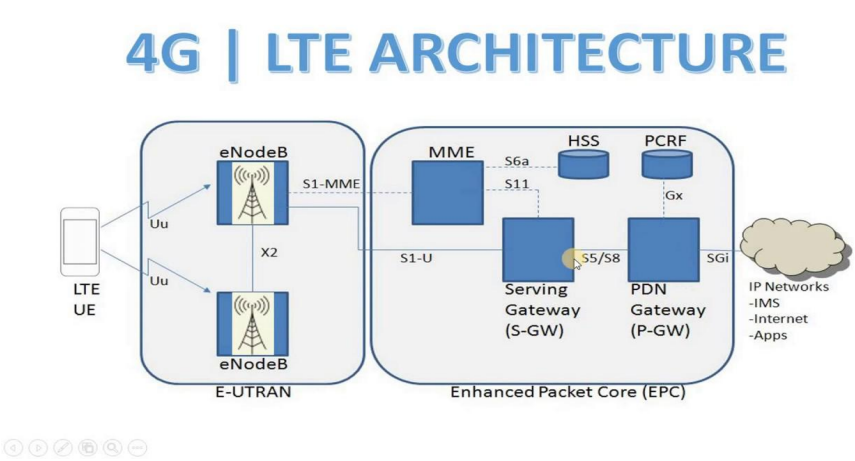
Long-Term Evolution (LTE) is a standard for wireless broadband communication for mobile devices and data terminals, based on the GSM/EDGE and UMTS/HSPA technologies. It increases the capacity and speed using a different radio interface together with core network improvements.

LTE offers high peak data transfer rates -- up to 100 Mbps downstream and 30 Mbps upstream. It also provides reduced latency, scalable bandwidth capacity and backward-compatibility with existing GSM and UMTS technology. Future developments could yield peak throughput on the order of 300 Mbps. [12]

LTE devices use QPSK, 16QAM and 64QAM to modulate data and control information. [13]

LTE bandwidths range from 15MHz to 200MHz

LTE is used for high speed Internet connections for mobile devices and it is also used in communication with VoLTE(Voice over LTE). [12]



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