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EXPERIMENT 1

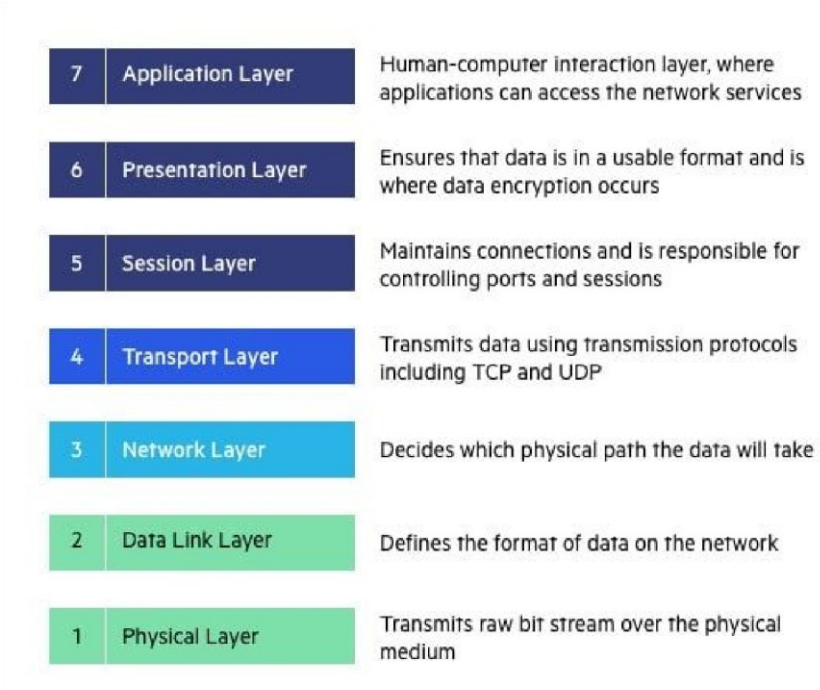
STUDY OF DIFFERENT TYPES OF PHYSICAL LAYER WIRED/WIRELESS CONNECTIONS

AIM:

To study different types of Physical Layer Wired/Wireless connections (Ethernet).

The OSI Model:

The Open Systems Interconnection (OSI) model describes seven layers that computer systems use to communicate over a network. It was the first standard model for network communications, adopted by all major computer and telecommunication companies in the early 1980s.



References:

OSI Model [1]

What is OSI Model | 7 Layers Explained

Physical Layer:

The lowest layer of the OSI reference model is the physical layer. It is responsible for the actual physical connection between the devices. The physical layer contains information in the form of bits. It is responsible for transmitting individual bits from one node to the next. When receiving data, this layer will get the signal received and convert it into 0s and 1s and send them to the Data Link layer, which will put the frame back together.

The functions of the physical layer are:

1. **Bit synchronization:** The physical layer provides the synchronization of the bits by providing a clock. This clock controls both sender and receiver thus providing synchronization at bit level.
2. **Bit rate control:** The Physical layer also defines the transmission rate i.e. the number of bits sent per second.
3. **Physical topologies:** Physical layer specifies the way in which the different devices/nodes are arranged in a network i.e. bus, star or mesh topology.
4. **Transmission mode:** Physical layer also defines the way in which the data flows between the two connected devices.

The various transmission modes possible are: Simplex, half-duplex and full-duplex.

References:

Physical layer Introduction and functions

https://www.geeksforgeeks.org/layers-of-osi-model/#:~:text=Physical%20Layer%20(Layer%201)%20%3A,one%20node%20to%20the%20next.

Transmission media

DCN - Physical Layer Introduction

Wired Connections:

Wired Network Connections- A wired network connection is described as a configuration that involves cables which establish a connection to the Internet and other devices on the network. Most wired networks use Ethernet cables to transfer data between connected PCs. In a small wired network, a single router may be used to connect all the computers. Larger networks often involve multiple routers or switches that connect to each other.

1. WHAT IS ETHERNET?

Ethernet is the traditional technology for connecting wired local area networks (LANs), enabling devices to communicate with each other via a protocol -- a set of rules or common network language.

As a data-link layer protocol, Ethernet describes how network devices can format and transmit data packets so other devices on the same local or campus area network segment can recognize, receive and process them. **An Ethernet cable is the physical, encased wiring over which the data travels.**

A. Range

There are different Ethernet standards. Their range have been specified below:

- 10Base2: These coaxial cables are like those used in television, but thinner. They are also called "thinnet" or "coax". Each computer has a "T" plugged into it, and cables plug into each side of the "T". Sometimes, instead of a "T", a vampire tap is used. It supports 10MBits per second transfer speed. 10BASE2 coax cables have a maximum length of 185 metres (607 ft). The maximum practical number of nodes that can be connected to a 10BASE2 segment is limited to 30 with a minimum distance of 50 centimetres (20 in) between devices.
- 10BaseT: Cables look like thick phone cables, but with 8 copper wires instead of 2 or 4, and they go from each computer' to a Hub or a Switch. Supported speed is 10 MBit/second. 10BASET have a maximum length of 100m and uses twisted pair of wires. Up to 1024 stations can be connected to it and it offers a bandwidth of 10 Mbit/s.
- 10Base5- 10BASE5 uses a thick and stiff coaxial cable up to 500 meters (1,600 ft) in length. Up to 100 stations can be connected to the cable using vampire taps and share a single collision domain with 10 Mbit/s of bandwidth shared among them

B. Encoding

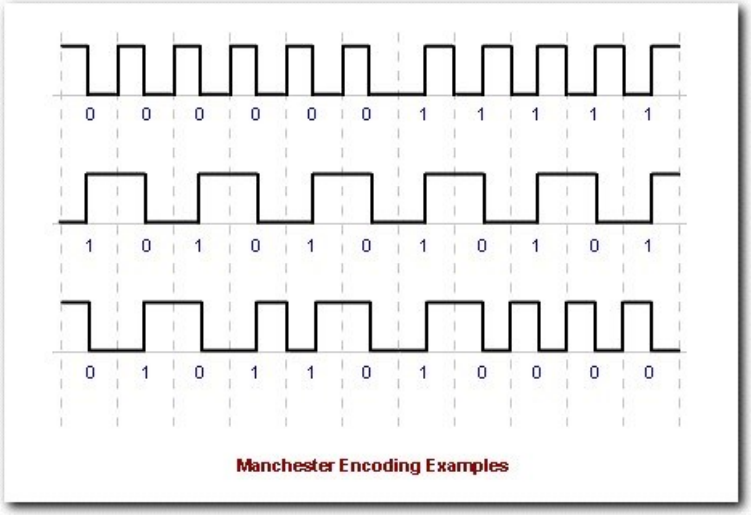
Manchester encoding is an encoding method commonly used on Legacy Ethernet networks.

There are two rules to follow using this encoding method...

- To send a logic '0' data bit, **increase** the voltage up from 0 to +V in the middle of the bit period.

- To send a logic '1' data bit, **decrease** the voltage down from +V to 0 in the middle of the bit period.

The diagram below illustrates this: -



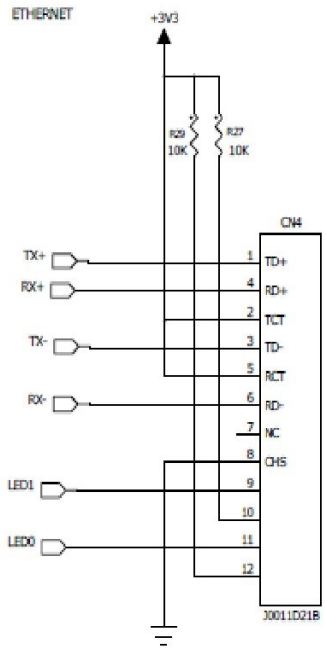
We can see that a high-to-low transition represents a logic '0' data bit and a low-to-high transition represents a logic '1' data bit.

C. Scalability

Ethernet is a family of computer networking technologies commonly used in local area networks (LAN), metropolitan area networks (MAN) and wide area networks (WAN).[1]

Ethernet is currently the most widely used technology in enterprise networking. Unfortunately, Ethernet exhibits scalability issues when used to build broadcast domains of more than a few thousand devices, such as costly and energy-dense address table logic and storms of broadcast traffic. The traditional method of avoiding such problems is the artificial subdivision of a network, but this introduces an administrative burden, requires significant routing equipment and with current protocols also precludes live migration.

D. Schematic View



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2. IEEE 1394 (FireWire)–

Also widely referred to as FireWire, IEEE 1394 was approved by the Institute of Electrical and Electronics Engineers (IEEE) in 1995. It was originally conceived by Apple.

IEEE 1394 is similar to the first version of USB in many ways, but much faster. Both are hotswappable serial interfaces, but IEEE 1394 provides high-bandwidth, high-speed data transfers significantly in excess of what USB offers. There are two levels of interface in IEEE 1394, one for the backplane bus within the computer and another for the point-to-point interface between device and computer on the serial cable.

A. Range –

Each IEEE 1394 bus segment may have up to 63 devices attached to it. Currently each device may be up to 4.5 metres apart; longer distances are possible with and without repeater hardware. Improvements to the current cabling are being specified to allow longer distance cables. Over 1000 bus segments may be connected by bridges thus providing a large growth potential. An additional feature is the ability of transactions at different speeds to occur on a single device medium.

B. Modulation

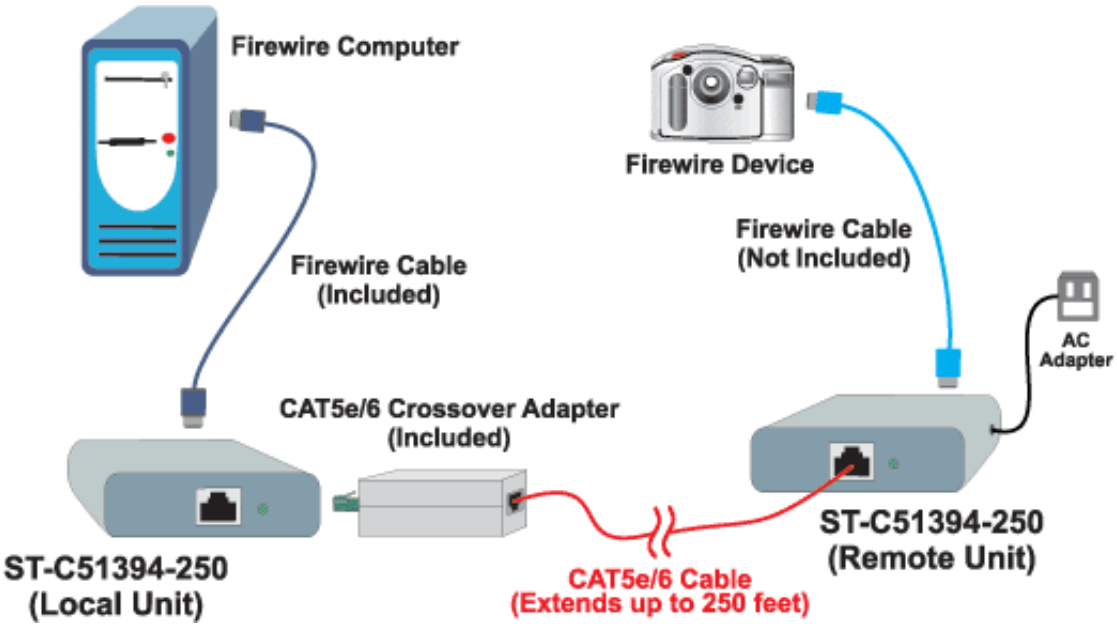
The current design in uses BPSK modulation at 2 GHz to transmit data across the transformer boundary, consuming approximately 15 mA.

C. Signalling

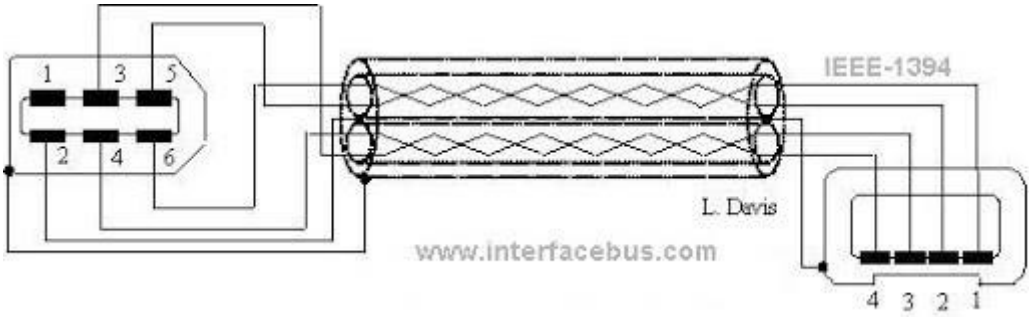
IEEE 1394 specifies two signalling mechanisms across the bus: common mode (DC) and differential. DC signalling means that a logical 1 is represented as a positive voltage, and a logical 0 is represented as zero voltage. In 1394, it is used for three purposes: device attachment and detection, speed signalling, and power management (suspend-resume). Differential signalling means that logic values are represented by the difference between two wires: if the voltage on one wire is greater than the next, then a logical 1 is represented, otherwise a logical 0 is represented. The advantage of this method is that power consumption is greatly reduced. As such, 1394 uses differential signalling for the majority of operations, such as bus reset, arbitration, configuration commands, and data packet transmission

D. Scalbility

PAN To enable data exchange, modern devices such as smartphones, tablets, laptops, and desktop computers can be integrated into a network. This can be wired in the form of a Personal Area Network (PAN). Common transfer techniques include **USB** or **FireWire.**



E. Schematic View



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- **IEEE 1394:**

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3. Etherloop

Etherloop is a kind of DSL technology that combines the features of Ethernet and DSL. It allows the combination of voice and data transmission on standard phone lines. Etherloop uses half-duplex transmission, and as such, is less susceptible to interference caused by poor line quality, bridge taps, etc.

A. Range

EtherLoop offers a data transfer rate up to 6 Mbps over distances of up to 21,000 feet.
Developed by Nortel, **EtherLoop**, unlike DSL, uses the half-duplex transmission of Ethernet.

B. Modulation

The Data Rate is determined by Modulation Level and Center Frequency

QPSK

(QAM4) 2

bits/symbol

QAM16 4

bits/symbol:

1 Msymb/sec *

4bits/symb =

4Mbps 1.67

Msymb/sec *

4bits/symb =

6.67Mbps

QAM64 6

bits/symbol:

1.67 Msymb/sec * 6bits/symb = 10Mbps

C. Signalling

For high quality subscriber loops EtherLoop is designed to use a range of frequencies from approximately 30 kHz to 3 MHz. This frequency range is divided up into 10 overlapping frequency spectra, only one of which is active at any point in time. The lowest spectrum has a total frequency range of 62.5 kHz, and the highest has a frequency range of 1.667 MHz. Historically speaking, one Hertz is equivalent to one symbol per second, which would give EtherLoop a theoretical maximum symbol rate of 1.667 megasymbols per second. Using standard signal modulation techniques, such as BPSK, which support 1 data bit per symbol, this would translate to 1.667 megabits per second.

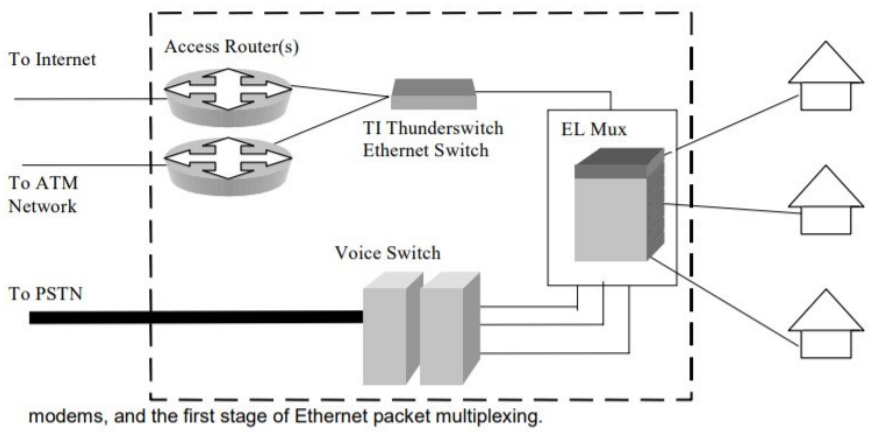
D. Scalability

There are five major markets where long-range Ethernet is a viable product:

- Residential Internet Access
- SOHO (Small Office Home Office) Internet and corporate access
- Hotel/Hospitality/Lodging Internet Access
- CAN (Campus Area Network) deployment
- Data T1 Replacement (LAN extension)

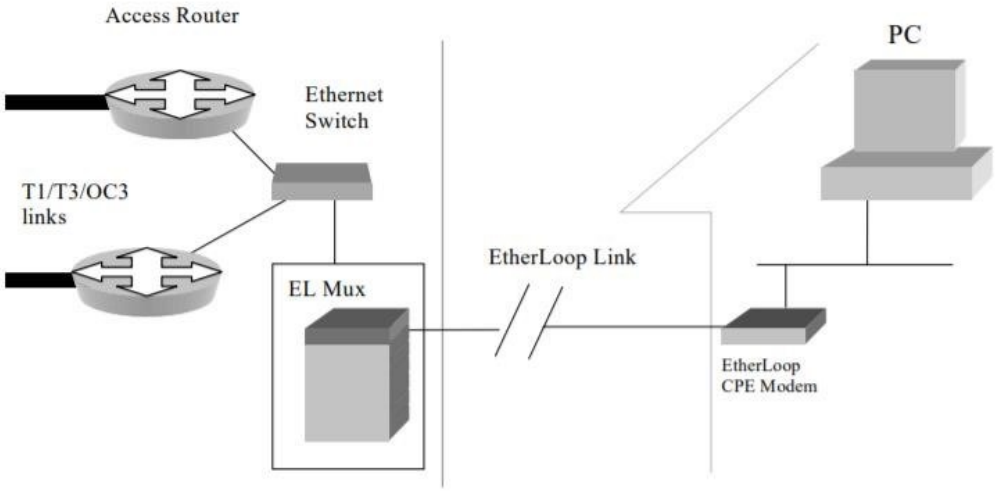
Central Office Configuration

The EtherLoop CO configuration is relatively straightforward. Each subscriber is brought back to an EtherLoop Multiplexer shelf product, which is EtherLoop ready. The voice and data channels are separated, and the voice channel is passed on to the PSTN switch. The data channel is passed on to a TI ThunderSWITCH Ethernet switch, which then connects to any standard TCP/IP or ATM network. Depending on the needs of the customer, multiple networks can be attached, for example, some users may wish to use the public Internet, some may wish to use the telco's regional broadband network, and some may wish to connect to private corporate networks.



Residential Access

The Residential access model is the most straightforward. The end-user will typically have only one device connected to the EtherLoop link, which simplifies the overall architecture.



SOHO Corporate Access

The SOHO model differs moderately from the residential access model. Typically, there will be a more extensive LAN in the subscriber's home/office than the residential user. In this case, modems must take on the additional responsibilities of bridging Ethernet traffic, keeping local traffic on the subscriber premises side of the link. This capability is already built into the EtherLoop modems. In that configuration, an external modem is more appropriate.

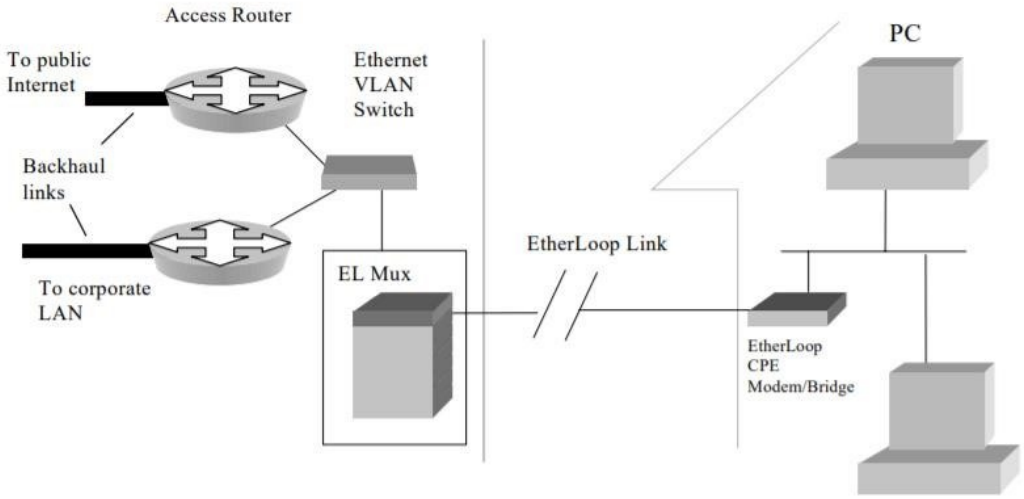
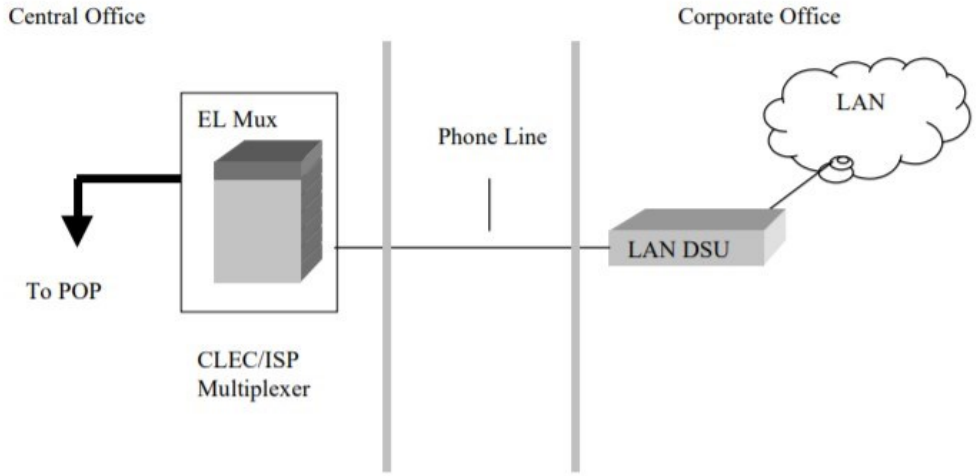


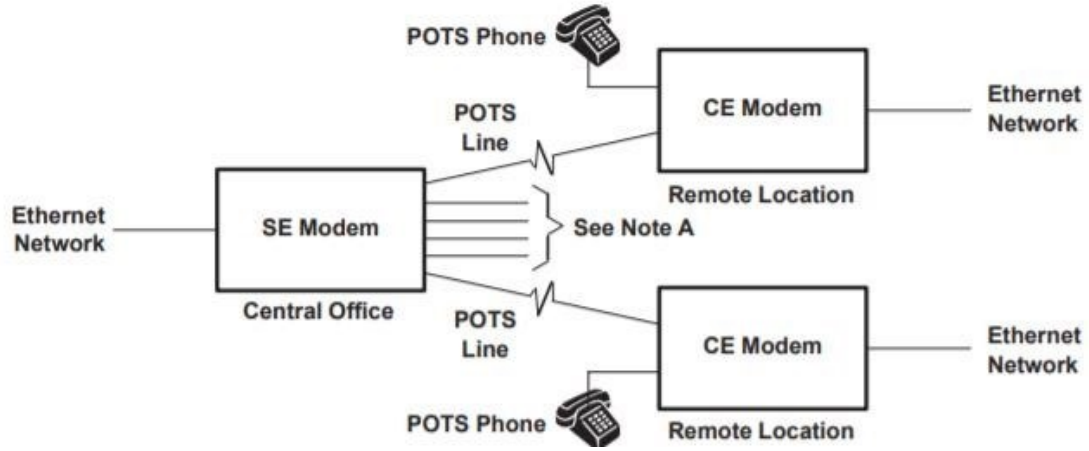
Figure 5: SOHO Corporate Access

Campus Networks/T1 Replacement

In a campus or downtown environment, EtherLoop can be used to provide data network access to corporations, universities or institutions at speeds of up to 10 megabits per second, over existing voice lines. In this environment, a rack-mounted EtherLoop LAN DSU will be installed at the customer premise, with a corresponding connection either in a central office, or at a nearby site, depending on the nature of the copper access regulations.



E. Schematic View



The above figure shows a typical system with an EtherLoop modem located at each end of the POTS line. Each EtherLoop modem has a 10Base-T Ethernet interface and is responsible for buffering Ethernet data before sending it over the POTS wire. The server-end (SE) EtherLoop modem is located in a central switching office and can communicate with several client-end (CE) EtherLoop modems, based on a round-robin arbitration scheme. The CE EtherLoop modem typically is located at a remote site.

References:

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- http://www.ic72.com/pdf_file/t/317096.pdf
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- https://www.ieee802.org/3/efm/public/jan01/stanley_1_01_2001.pdf
- https://searchnetworking.techtarget.com/definition/EtherLoop

4. Coaxial Cable

Coaxial cable, or **coax** is a type of electrical cable consisting of an inner conductor surrounded by a concentric conducting shield, with the two separated by a dielectric (insulating material); many coaxial cables also have a protective outer sheath or jacket. The term "coaxial" refers to the inner conductor and the outer shield sharing a geometric axis.

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.

A. Range

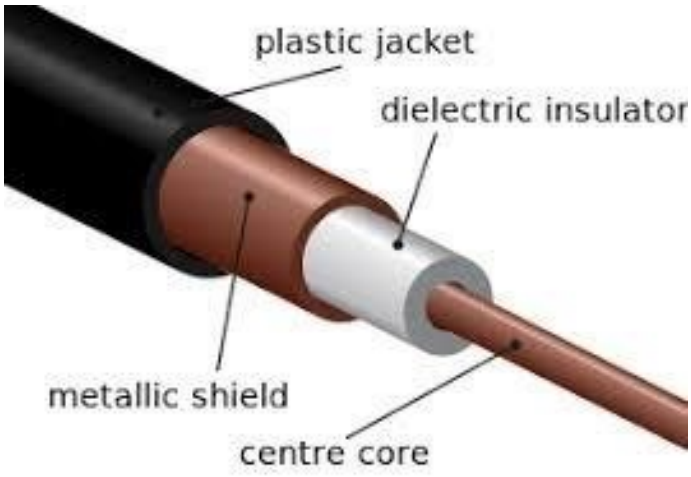
Coaxial cable can be cabled over longer distances than twisted-pair cable. For example, Ethernet can run approximately 100 meters (328 feet) using twisted-pair cabling. Using coaxial cable increases this distance to 500m (1640.4 feet).

B. Scalability

There are two types of coaxial cable

1. RG8 used in LAN also known as thick Ethernet.
2. RG-58 used for LAN and known as thin Ethernet.

C. Schematic View



5. Twisted Pair Cable

One of the earliest guided transmission media is twisted pair cables. A twisted pair cable comprises of two separate insulated copper wires, which are twisted together and run in parallel. The copper wires are typically 1mm in diameter. One of the wires is used to transmit data and the other is the ground reference.

A. Types-

There are two types of twisted pair cables −

a) **Unshielded Twisted Pair (UTP):** These generally comprise of wires and insulators. They are the defacto standard for Ethernet cabling system. UTP cables are twisted in helical fashion like a strand of a DNA. Twisted are introduced for a special purpose. UTP cables are also used in telephone lines. Unlike older landline telephones, there are no incidents of crosstalk in current landline phones due to UTP cables twisted design. In networking, the twists help avoid data leakage. The commonly used UTP copper cable is Cat5, Cat5e, Cat6, Cat6a and Cat7. o **Range-**

UTP Category	Data Rate	Max. Length
CAT1	Up to 1Mbps	-
CAT2	Up to 4Mbps	-
CAT3	Up to 10Mbps	100m
CAT4	Up to 16Mbps	100m
CAT5	Up to 100Mbps	100m
CAT5e	Up to 1 Gbps	100m
CAT6	Up to 10Gbps	100m
CAT6a	Up to 10Gbps	100m
CAT7	Up to 10Gbps	100m

- **Modulation -** Data is encoded using 4D-PAM5; four dimensions using PAM (pulse amplitude modulation) with five voltages, −2 V, −1 V, 0 V, +1 V, and +2 V.[12] While +2 V to −2 V may appear at the pins of the line driver, the voltage on the cable is nominally +1 V, +0.5 V, 0 V, −0.5 V and −1 V.[13]

b) **Shielded Twisted Pair (STP):** They have a braided wired mesh that encases each pair of insulated wires. Shielded' with a foil jacket to cancel any external interference. Used primarily for large-scale enterprises, high-end applications, and exterior cabling that will be exposed to environmental elements.

- Range – Up to 100m o Bandwidth – Up to 750 MHz. o Modulation – Line coding is used here. Line coding is the modulation of an electrical charge so that each side of a connection knows what is a one and what is a zero.

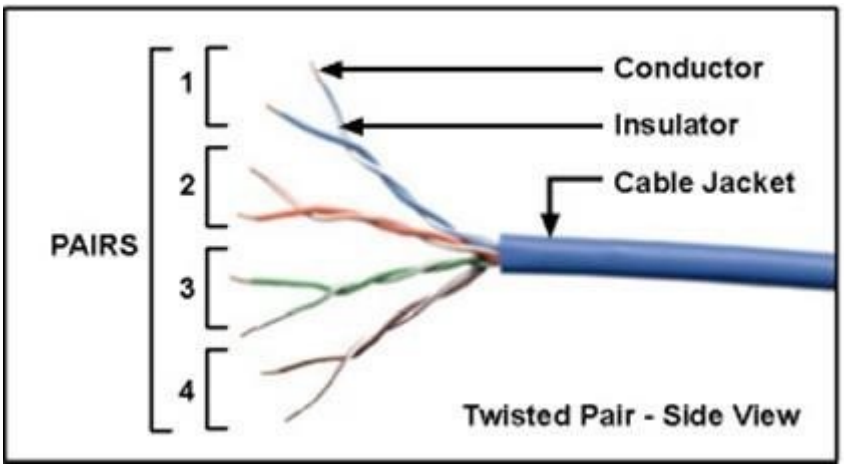
B. Scalability

EIA has classified twisted pair cables into seven categories −

- Category 1 − UTP used in telephone lines with data rate < 0.1 Mbps

- Category 2 − UTP used in transmission lines with a data rate of 2 Mbps
- Category 3 − UTP used in LANs with a data rate of 10 Mbps
- Category 4 − UTP used in Token Ring networks with a data rate of 20 Mbps
- Category 5 − UTP used in LANs with a data rate of 100 Mbps
- Category 6 − UTP used in LANs with a data rate of 200 Mbps
- Category 7 − STP used in LANs with a data rate of 10 Mbps

C. Schematic View



References:

- **Coaxial Cable-**
- https://www.ciscopress.com/articles/article.asp?p=31276&seqNum=2#:~:text=Coaxial%20cable%20can%20be%20cabled,to%20500m%20(1640.4%20feet).

- https://en.wikipedia.org/wiki/Coaxial_cable **Twisted Pair Cable**
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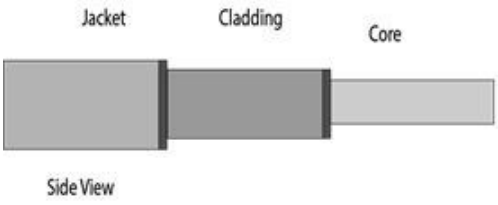
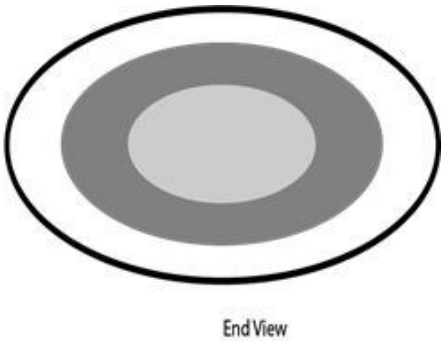
- https://en.wikipedia.org/wiki/Wireless_LAN

6. Fiber Optic Cable:

- Fiber optic cable is a cable that uses electrical signals for communication.
- Fiber optic is a cable that holds the optical fibers coated in plastic that are used to send the data by pulses of light.
- The plastic coating protects the optical fibers from heat, cold, electromagnetic interference from other types of wiring.
- Fiber optics provide faster data transmission than copper wires.

Diagrammatic representation of fiber optic cable:





Scalability
Used in CAN networks.

References:

https://www.brainkart.com/article/Wired-Technologies-and-its-types_36827/

Wireless Networks:

1. Wifi

Wi-Fi is a wireless networking technology that allows devices such as computers (laptops and desktops), mobile devices (smartphones and wearables), and other equipment (printers and video cameras) to interface with the Internet. It allows these devices--and many more--to exchange information with one another, creating a network.

Internet connectivity occurs through a wireless router. When you access Wi-Fi, you are connecting to a wireless router that allows your Wi-Fi-compatible devices to interface with the Internet.

Specifications:

Range:

- A wireless network's range can vary wildly depending on the type of network. A standard home network using one wireless router can serve a single-family dwelling, but often not much more.
- Business networks with grids of access points can serve large office buildings, and wireless hotspots spanning several square miles have been built in some cities.
- A general rule of thumb in home networking says that Wi-Fi routers operating on the 2.4 GHz band can reach up to 150 feet indoors and 300 feet outdoors. Older 802.11a routers that ran on 5 GHz bands reached approximately one-third of these distances.
- Newer 802.11n and 802.11ac routers that operate on both 2.4 GHz and 5 GHz bands reach greater distances.

Modulation:

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 code keying (CCK). The bitstream is processed with a special coding and then modulated using Quadrature Phase Shift Keying (QPSK).

Wi-Fi Scalability :

- Compared to cell phones and similar technology, Wi-Fi transmitters are low power devices. In general, the maximum amount of power that a Wi-Fi device can transmit is limited by local regulations, such as FCC Part 15 in the US. Equivalent isotropically radiated power (EIRP) in the European Union is limited to 20 dBm (100 mW).
- To reach requirements for wireless LAN applications, Wi-Fi has higher power consumption compared to some other standards designed to support wireless personal area network (PAN) applications.

References:

Wifi:
What Is Wi-Fi? - Definition and Types

2. 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.

A. Range

Class	Typ. range[2] (m)
1	~100
1.5	~20
2	~10
3	~1
4	~0.5

B. Modulation and Signalling

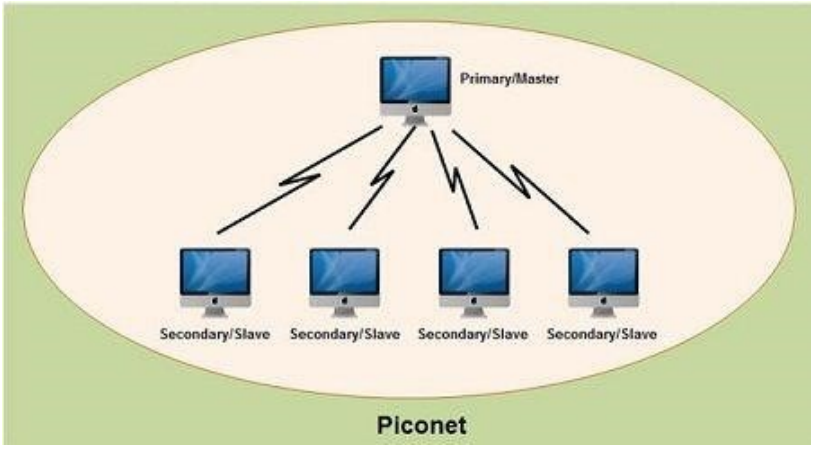
Based on the modulation scheme, multiple symbols may be used to represent a single bit, or a single symbol could potentially represent multiple bits.

With BLE modulation specifically, a zero is coded to negative frequency deviation of at least 185kHz, and a 1 is coded to a positive frequency deviation of at least the same amount. At just the physical layer, BLE is capable of transmitting 1 million symbols per second. This translates to 1 Mbps assuming an encoding of 1 bit per symbol (which is standard for BLE). This threshold in the symbol rate is due to a limitation caused by intersymbol interference. Also, this is an idealized value

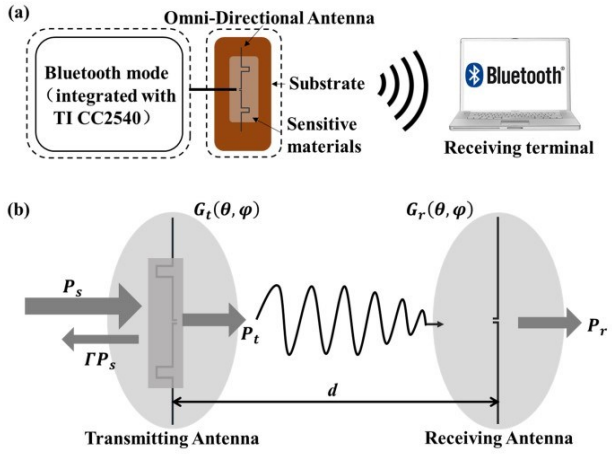
that doesn’t take into account factors such as packet overhead.

C. Scalability

To enable data exchange, modern devices such as smartphones, tablets, laptops, and desktop computers can be integrated into a network. This can be wired in the form of a Personal Area Network (PAN). The wireless variety is known as **Wireless Personal Area Network (WPAN)** and is based on technologies such as Bluetooth, Wireless USB, Insteon, IrDA, ZigBee, and Z-Wave. A wireless Personal Area Network, which can be achieved via Bluetooth, is called **Piconet**. PANs and WPANs usually only stretch over a few meters, and are therefore not suitable for connecting devices in different rooms or even buildings.



D. Schematic View



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• https://en.wikipedia.org/wiki/Bluetooth

3. LTE

In telecommunications, 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 is the upgrade path for carriers with both GSM/UMTS networks and CDMA2000 networks. The different LTE frequencies and bands used in different countries mean that only multi-band phones are able to use LTE in all countries where it is supported.

A. Range

LTE is required to support communication with terminals moving at speeds of up to 350 km/h, or even up to 500 km/h depending on the frequency band. The primary scenario for operation at such high speeds is usage on high-speed trains – a scenario which is increasing in importance across the world as the number of high-speed rail lines increases and train operators aim to offer an attractive working environment to their passengers. These requirements mean that handover between cells has to be possible without interruption – in other words, with imperceptible delay and packet loss for voice calls, and with reliable transmission for data services. These targets are to be achieved by the LTE system in typical cells of radius up to 5 km, while operation should continue to be possible for cell ranges of 100km and more, to enable wide-area deployments.

B. Modulation

LTE is based on Orthogonal Frequency Division Multiple Access (OFDM), and achieves high data rates by combining large bandwidths, higher order modulation and spatial multiplexing. There are multi path fading problems in UMTS so LTE uses OFDM in the downlink to overcome such problems.

Orthogonal frequency-division multiplexing (OFDM) is a method for encoding digital data transmission which uses a large number of closely spaced carriers that are modulated with low rate data stream. By making the signal orthogonal to each other, the signals would not interfere with other signals and thus mutual interference is avoided. By carrying the data at a lower rate across all carriers, the effects of reflections and inter-symbol interference are also overcome. If some of the carriers

are lost due to multi-path effects, then the data can be reconstructed by using error correction techniques.

C. Signalling

The LTE specification provides downlink peak rates of 300 Mbit/s, uplink peak rates of 75 Mbit/s and QoS provisions permitting a transfer latency of less than 5 ms in the radio access network. LTE has the ability to manage fast-moving mobiles and supports multi-cast and broadcast streams. LTE supports scalable carrier bandwidths, from 1.4 MHz to 20 MHz and supports both frequency division duplexing (FDD) and time-division duplexing (TDD). The IP-based network architecture, called the Evolved Packet Core (EPC) designed to replace the GPRS Core Network, supports seamless handovers for both voice and data to cell towers with older network technology such as GSM, UMTS and CDMA2000.[21] The simpler architecture results in lower operating costs (for example, each E-UTRA cell will support up to four times the data and voice capacity supported by HSPA[22]).

Frequencies used for LTE-TDD range from 1850 MHz to 3800 MHz, with several different bands being used.

D. Scalability

Wireless wide area network (**WWAN**), is a form of wireless network. The larger size of a wide area network compared to a local area network requires differences in technology. Wireless networks of different sizes deliver data in the form of telephone calls, web pages, and streaming video.

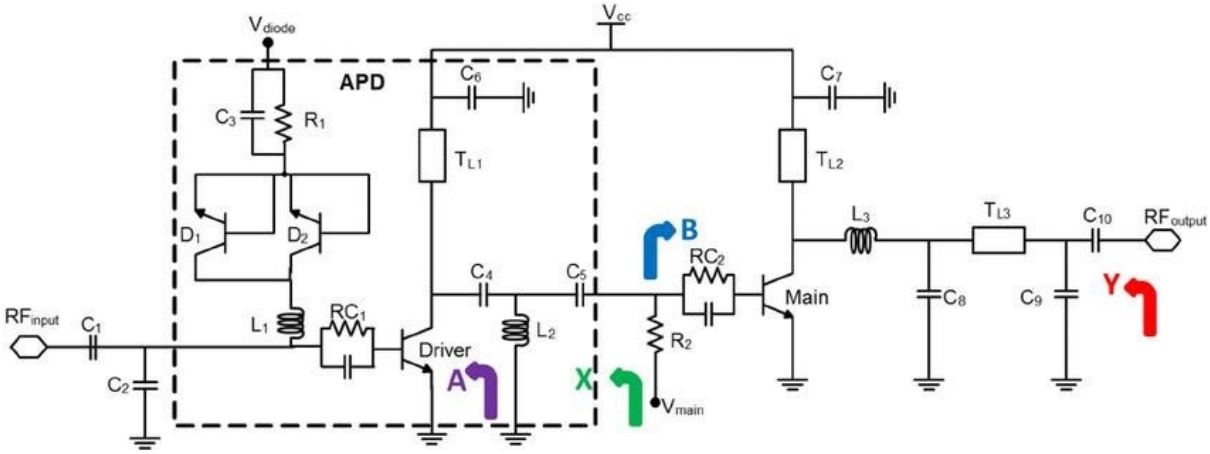
A WWAN often differs from wireless local area network (WLAN) by using mobile telecommunication cellular network technologies such as 2G, 3G, 4G LTE, and 5G to transfer data. These technologies are offered regionally, nationwide, or even globally and are provided by a wireless service provider. WWAN connectivity allows a user with a laptop and a WWAN card to surf the web, check email, or connect to a virtual private network (VPN) from anywhere within the regional boundaries of cellular service. Various computers can have integrated WWAN capabilities.

A WWAN may also be a closed network that covers a large geographic area. For example, a mesh network or MANET with nodes on buildings, towers, trucks, and planes could also be considered a WWAN.

A WWAN may also be a low-power, low-bit-rate wireless WAN, (LPWAN), intended to carry small packets of information between things, often in the form of battery operated sensors.

Since radio communications systems do not provide a physically secure connection path, WWANs typically incorporate encryption and authentication methods to make them more secure. Some of the early GSM encryption techniques were flawed, and security experts have issued warnings that cellular communication, including WWAN, is no longer secure.[1] UMTS (3G) encryption was developed later and has yet to be broken.

E. Schematic View



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4. Zigbee-

Zigbee is a wireless technology developed as an open global standard to address the unique needs of low-cost, low-power wireless IoT networks. The Zigbee standard operates on the IEEE 802.15. 4 physical radio specification and operates in unlicensed bands including 2.4 GHz, 900 MHz and 868 MHz.

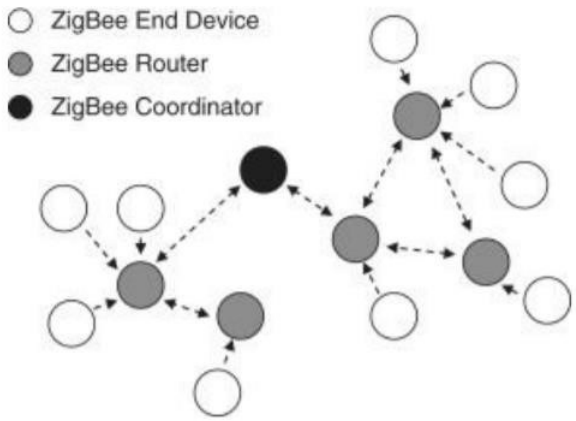
A. Range-

Its low power consumption limits transmission distances to 10–100 meters line-of-sight, depending on power output and environmental characteristics. Zigbee devices can transmit data over long distances by passing data through a mesh network of intermediate devices to reach more distant ones. Data range is 250 kbps and the number of nodes that can be connected are around 64,000.

B. Modulation-

Zigbee modulation is carried out through direct sequence spread spectrum (DSSS). The 2.4 GHz band, in which ZigBee transceivers are most commonly deployed, uses the OQPSK (offset quadrature phase-shift keying) modulation stream.

C. Schematic Diagram



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5. WiMax

WiMAX (**Worldwide Interoperability for Microwave Access**) is a family of wireless broadband communication standards based on the IEEE 802.16 set of standards, which provide multiple physical layer (PHY) and Media Access Control (MAC) options.

The name "WiMAX" was created by the WiMAX Forum, which was formed in June 2001 to promote conformity and interoperability of the standard, including the definition of predefined system profiles for commercial vendors.[1] The forum describes WiMAX as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL".[2] IEEE 802.16m or WirelessMAN-Advanced was a candidate for the 4G, in competition with the LTE Advanced standard.

A. Range

WiMAX outdistances WiFi by miles. WiFi's range is about 100 feet (30 m). WiMAX will blanket a radius of **30 miles** (50 km) with wireless access. The increased range is due to the frequencies used and the power of the transmitter. Of course, at that distance, terrain, weather and large buildings will act to reduce the maximum range in some circumstances, but the potential is there to cover huge tracts of land.

B. Modulation

PARAMETER	DOWNLINK	UPLINK
Modulation	BPSK, QPSK, 16 QAM, 64 QAM; BPSK optional for OFDMA- BPSK, QPSK, 16 QAM; 64 QAM PHY optional	

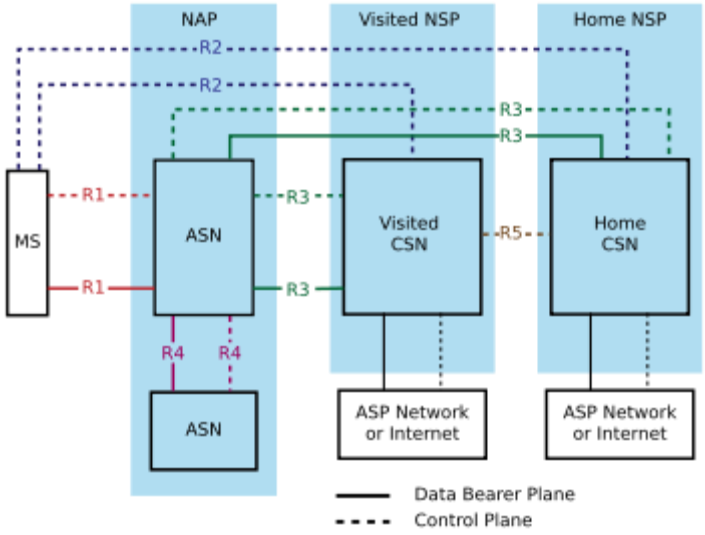
C. Signalling

- Speed - 70 megabits per second
- Line-of-sight not needed between user and base station
- Frequency bands - 2 to 11 GHz and 10 to 66 GHz (licensed and unlicensed bands)

D. Scalability

WiMAX is the wireless solution for the next step up in scale, the metropolitan area network (MAN). A MAN allows areas the size of cities to be connected. WiMAX provides metropolitan area network (MAN) connectivity at speeds of up to 75 Mb/sec. WiMAX systems can be used to transmit signal as far as 30 miles. As WiMax can support data ranges across miles, it is well suited for a country such as India where telecom infrastructure is poor and last mile access is expensive. This ability lets ISPs players offer broadband access directly to homes without worrying about the problems of installing the last mile through optic fibre or cables. WiMax is also a big boon for telecom companies as it enables these companies to serve customers in rural areas without spending billions installing expensive infrastructure for minimal returns.

E. Schematic View



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6. Z-Wave

Z-Wave is a wireless communications protocol used primarily for home automation. It is a mesh network using low-energy radio waves to communicate from appliance to appliance,[1] allowing for wireless control of residential appliances and other devices, such as lighting control, security systems, thermostats, windows, locks, swimming pools and garage door openers.[2][3] Like other protocols and systems aimed at the home and office automation market, a Z-Wave system can be controlled via the Internet from a smart phone, tablet or computer, and locally through a smart speaker, wireless keyfob, or wall-mounted panel with a Z-Wave gateway.

A. Range

Z-Wave has a range of 100 meters or 328 feet in open air, building materials reduce that range. The more line powered devices in your Z-Wave network, the better, as they also act as repeaters to extend the Z-Wave signal. Z-Wave's mesh networking allows a Z-Wave signal to "hop" through other Z-Wave products to reach the destination device to be controlled. ZWave supports up to 4 hops so the total home coverage will grow depending on the amount of Z-Wave products in the network. The maximum range with 4 hops is roughly 600 feet or 200 meters.

B. Modulation

Data Rate Designation	Modulation	Coding	Symbols
R1	FSK	Manchester	Binary
R2	FSK	NRZ	Binary
R3	GFSK (BT=0.6)	NRZ	Binary

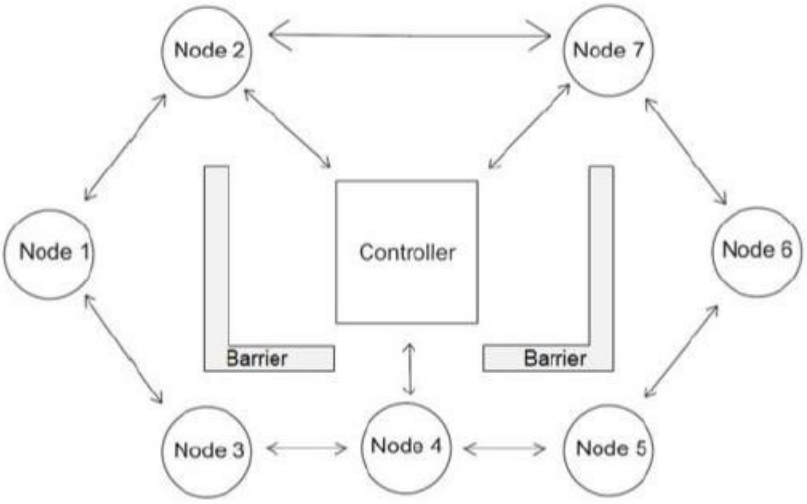
C. Signalling

It operates at 868.42 MHz in Europe, at 908.42 MHz in the North America and uses other frequencies in other countries depending on their regulations. Data rates include 9600 bps and 40 kbps, with output power at 1 mW.

D. Scalability

Z-Wave can be used within a network (Home Area Network, HAN), and can, therefore, be used to set up all areas of home automation, possibly controlled by a single controller. A mesh topology allows any node to connect to any other node and allows multiple connections.

E. Schematic View



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Z-Wave

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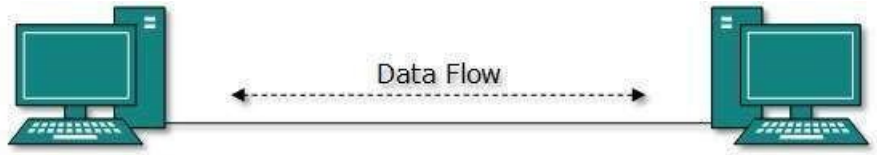
Network Topology:

A Network Topology is the arrangement with which computer systems or network devices are connected to each other. Topologies may define both physical and logical aspect of the network. Both logical and physical topologies could be same or different in a same network

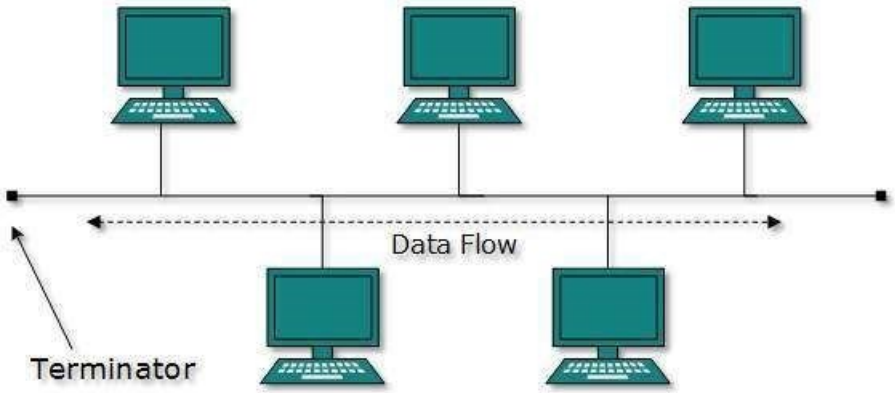
Point-to-Point

Point-to-point networks contains exactly two hosts such as computer, switches or routers, servers connected back to back using a single piece of cable. Often, the receiving end of one host is connected to sending end of the other and vice-versa.



Bus Topology

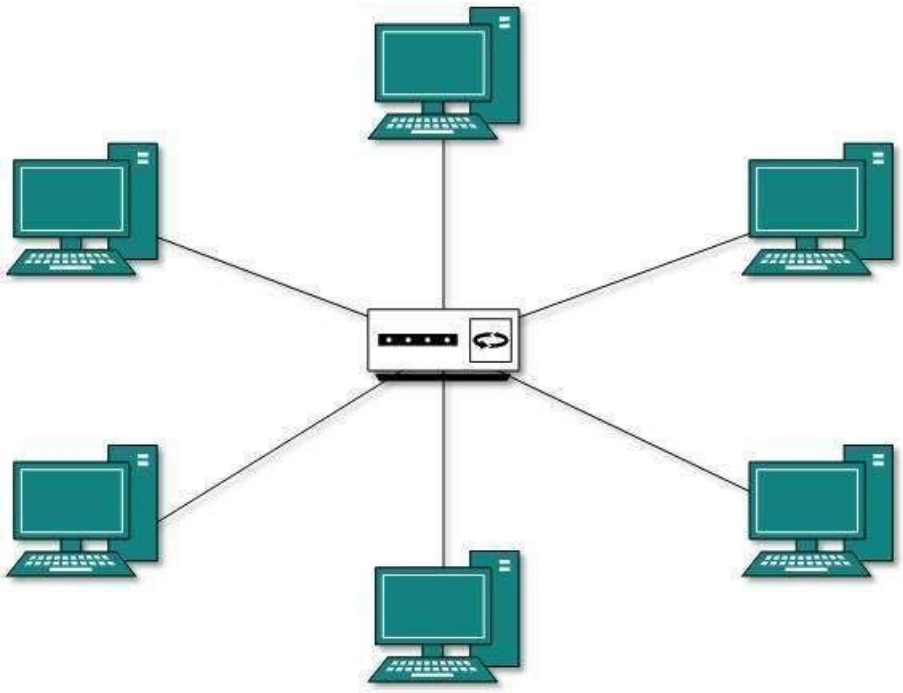
In case of Bus topology, all devices share single communication line or cable.Bus topology may have problem while multiple hosts sending data at the same time. Therefore, Bus topology either uses CSMA/CD technology or recognizes one host as Bus Master to solve the issue. It is one of the simple forms of networking where a failure of a device does not affect the other devices. But failure of the shared communication line can make all other devices stop functioning.



Star Topology

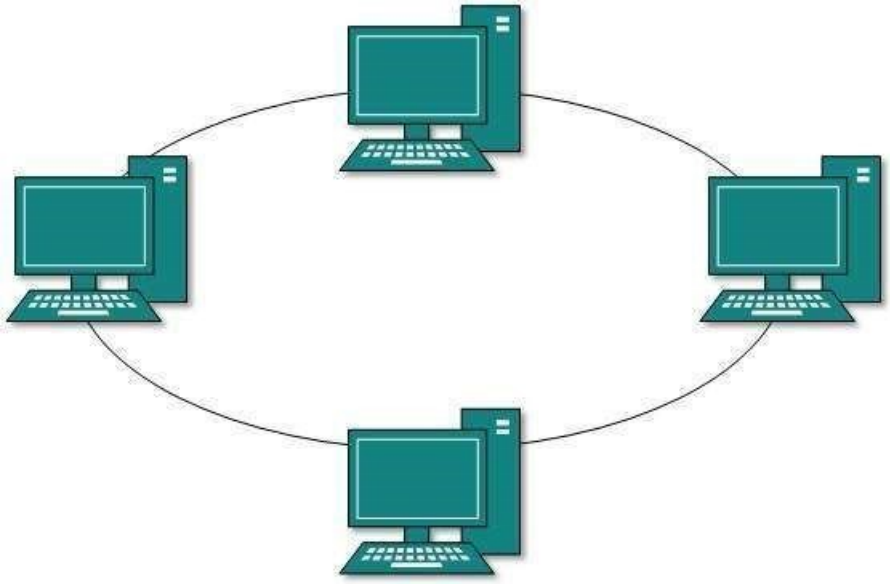
All hosts in Star topology are connected to a central device, known as hub device, using a point-to-point connection. That is, there exists a point to point connection between hosts and hub. The hub device can be any of the following:

- Layer-1 device such as hub or repeater
- Layer-2 device such as switch or bridge
- Layer-3 device such as router or gateway



Ring Topology

In ring topology, each host machine connects to exactly two other machines, creating a circular network structure. When one host tries to communicate or send message to a host which is not adjacent to it, the data travels through all intermediate hosts. To connect one more host in the existing structure, the administrator may need only one more extra cable

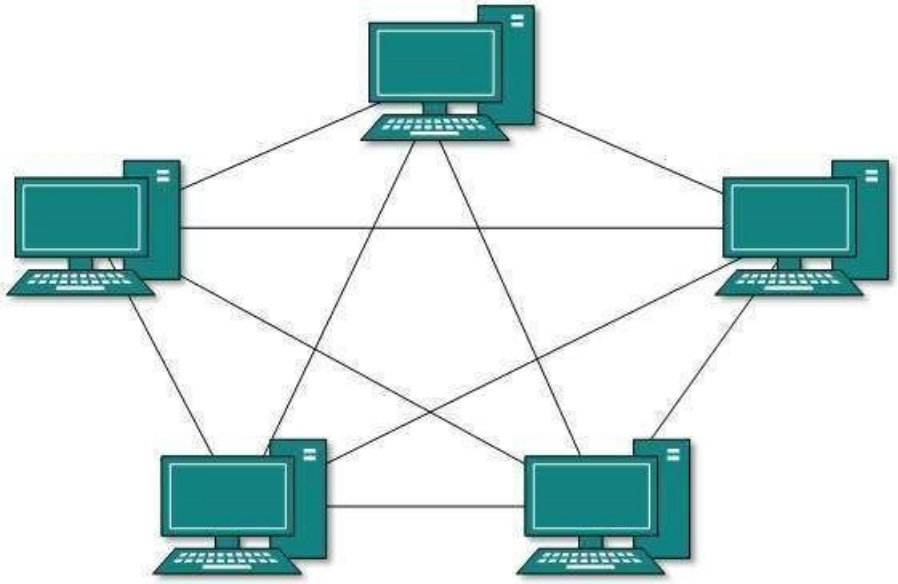


Mesh Topology

In this type of topology, a host is connected to one or multiple hosts.This topology has hosts in point-to-point connection with every other host or may also have hosts which are in point-to-point connection to few hosts only.

Hosts in Mesh topology also work as relay for other hosts which do not have direct pointto-point links. Mesh technology comes into two types:

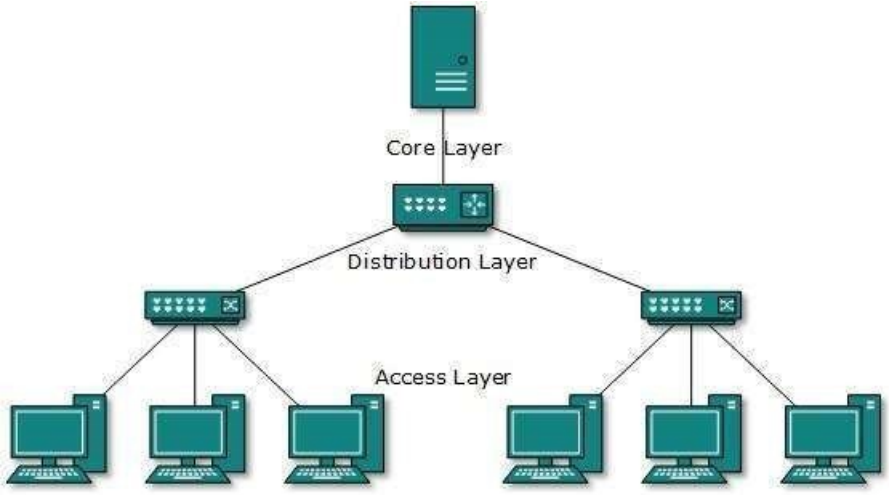
- Full Mesh: All hosts have a point-to-point connection to every other host in the network. Thus for every new host n(n-1)/2 connections are required. It provides the most reliable network structure among all network topologies.
- Partially Mesh: Not all hosts have point-to-point connection to every other host. Hosts connect to each other in some arbitrarily fashion. This topology exists where we need to provide reliability to some hosts out of all.



Tree Topology

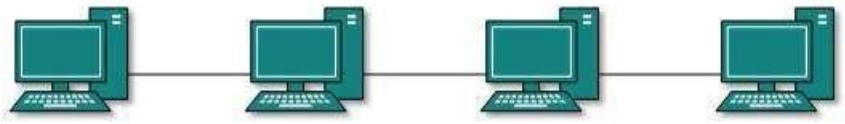
Also known as Hierarchical Topology, this is the most common form of network topology in use presently.This topology imitates as extended Star topology and inherits properties of bus topology.

This topology divides the network in to multiple levels/layers of network. Mainly in LANs, a network is bifurcated into three types of network devices. The lowermost is access-layer where computers are attached. The middle layer is known as distribution layer, which works as mediator between upper layer and lower layer. The highest layer is known as core layer, and is central point of the network, i.e. root of the tree from which all nodes fork.



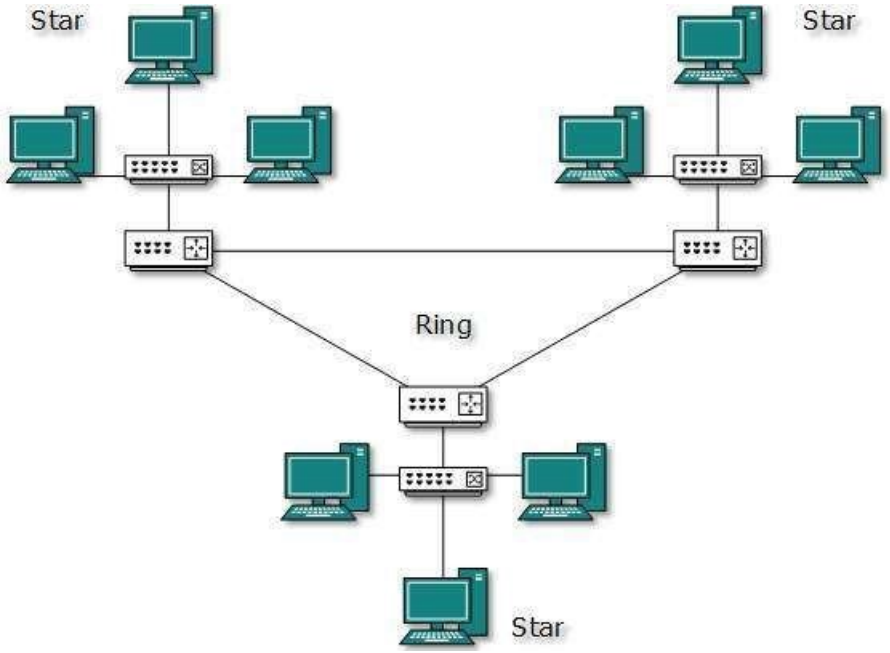
Daisy Chain

This topology connects all the hosts in a linear fashion. Similar to Ring topology, all hosts are connected to two hosts only, except the end hosts.Means, if the end hosts in daisy chain are connected then it represents Ring topology.



Hybrid Topology

A network structure whose design contains more than one topology is said to be hybrid topology. Hybrid topology inherits merits and demerits of all the incorporating topologies.



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Types of Networks:

1. Personal Area Network (PAN):

The smallest and most basic type of network, a PAN is made up of a wireless modem, a computer or two, phones, printers, tablets, etc., and revolves around one person in one building. These types of networks are typically found in small offices or residences, and are managed by one person or organization from a single device.PAN can be implemented using bluetooth, Wi-Fi, USB.

2. Local Area Network (LAN):

We're confident that you've heard of these types of networks before – LANs are the most frequently discussed networks, one of the most common, one of the most original and one of the simplest types of networks. LANs connect groups of computers and low-voltage devices together across short distances (within a building or between a group of two or three buildings in close proximity to each other) to share information and resources. Enterprises typically manage and maintain LANs.LAN can be implemented using Ethernet. Using routers, LANs can connect to wide area networks (WANs, explained below) to rapidly and safely transfer data.

3. Wireless Local Area Network (WLAN):

Functioning like a LAN, WLANs make use of wireless network technology, such as WiFi. Typically seen in the same types of applications as LANs, these types of networks don't require that

devices rely on physical cables to connect to the network.WLAN can be 12 implemented using Wi-Fi.

4. Campus Area Network (CAN):

Larger than LANs, but smaller than metropolitan area networks (MANs, explained below), these types of networks are typically seen in universities, large K-12 school districts or small businesses. They can be spread across several buildings that are fairly close to each other so users can share resources.CAN can be implemented using Optical Fibre, Transfer Jet.

5. Metropolitan Area Network (MAN):

These types of networks are larger than LANs but smaller than WANs – and incorporate elements from both types of networks. MANs span an entire geographic area (typically a town or city, but sometimes a campus). Ownership and maintenance is handled by either a single person or company (a local council, a large company, etc. MAN can be implemented using modems and cables.

6. Wide Area Network (WAN):

Slightly more complex than a LAN, a WAN connects computers together across longer physical distances. This allows computers and low-voltage devices to be remotely connected to each other over one large network to communicate even when they're miles apart. The Internet is the most basic example of a WAN, connecting all computers together around the world. Because of a WAN's vast reach, it is typically owned and maintained by multiple administrators or the public.WAN can be implemented using microwaves, optical fibres and satellites.

7. Storage-Area Network (SAN):

As a dedicated high-speed network that connects shared pools of storage devices to several servers, these types of networks don't rely on a LAN or WAN. Instead, they move storage resources away from the network and place them into their own high-performance network. SANs can be accessed in the same fashion as a drive attached to a server. Types of storage-area networks include converged, virtual and unified SANs.SAN can be implemented using optical fibre.

8. Passive Optical Local Area Network (POLAN):

As an alternative to traditional switch-based Ethernet LANs, POLAN technology can be integrated into structured cabling to overcome concerns about supporting traditional Ethernet protocols and network applications such as PoE (Power over Ethernet). A pointto-multipoint LAN architecture, POLAN uses optical splitters to split an optical signal from one strand of singlemode optical fiber into multiple signals to serve users and devices.

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