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TECOMPS - 34

Aim : Study of different types of physical layer wired or wireless connections.

INTRODUCTION TO PHYSICAL LAYER :[1]

Physical layer in the OSI model plays the role of interacting with actual hardware and signaling mechanism. Physical layer is the only layer of OSI network model which actually deals with the physical connectivity of two different stations. This layer defines the hardware equipment, cabling, wiring, frequencies, pulses used to represent binary signals etc.

Physical layer provides its services to Data-link layer. Data-link layer hands over frames to physical layer. Physical layer converts them to electrical pulses, which represent binary data. The binary data is then sent over the wired or wireless media.

Signals :

When data is sent over physical medium, it needs to be first converted into electromagnetic signals. Data itself can be analog such as human voice, or digital such as file on the disk. Both analog and digital data can be represented in digital or analog signals.

Digital Signals :

Digital signals are discrete in nature and represent sequence of voltage pulses. Digital signals are used within the circuitry of a computer system.

Analog Signals :

Analog signals are in continuous wave form in nature and represented by continuous electromagnetic waves.

The physical layer provides the following services:

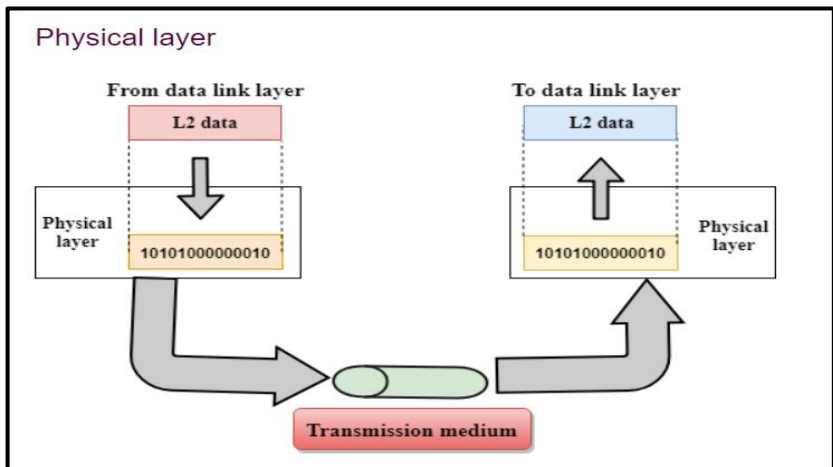
- Modulates the process of converting a signal from one form to another so that it can be physically transmitted over a communication channel.
- Bit-by-bit delivery.
- Line coding, which allows data to be sent by hardware devices that are optimized for digital communications that may have discreet timing on the transmission link.
- Bit synchronization for synchronous serial communications.
- Start-stop signaling and flow control in asynchronous serial communication.
- Circuit switching and multiplexing hardware control of multiplexed digital signals.
- Carrier sensing and collision detection, whereby the physical layer detects carrier availability and avoids the congestion problems caused by undeliverable packets.
- Signal equalization to ensure reliable connections and facilitate multiplexing.
- Forward error correction/channel coding such as error correction code.
- Bit interleaving to improve error correction.

- Auto-negotiation.
- Transmission mode control.

Examples of network that use physical layers include:

- Digital Subscriber Line.
- Integrated Services Digital Network.
- Infrared Data Association.
- Universal Serial Bus (USB.)
- Bluetooth.
- Controller Area Network.
- Ethernet.

Schematic representation of physical layer :



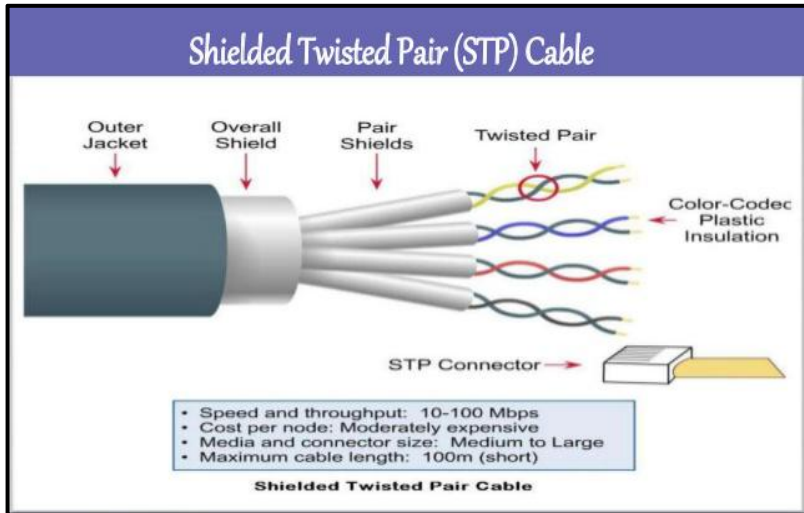
Types of wired connections :[2]

(1) Shielded twisted pair :

Shielded twisted pair is a special kind of copper telephone wiring used in some business installations. An outer covering or shield is added to the ordinary twisted pair telephone wires; the shield functions as a ground.

Twisted pair is the ordinary copper wire that connects home and many business computers to the telephone company. To reduce crosstalk or electromagnetic induction between pairs of wires, two insulated copper wires are twisted around each other. Each signal on twisted pair requires both wires. Since some telephone sets or desktop locations require multiple connections, twisted pair is sometimes installed in two or more pairs, all within a single cable. Shielded twisted pair is often used in business installations. The more common kind of wire that is installed to your home is *unshielded twisted pair*.

Schematic representation of Shielded twisted pair :



Advantages of shielded twisted pair cable (STP):

- Shielding reduces the chance of crosstalk and provides protection from interference.
- It offers better electrical characteristics than unshielded cables.
- It can be easily terminated with a modular connector.

Disadvantages of shielded twisted pair cable (STP):

- It has a higher cost per foot of wire.
- Shield of STP cables must be grounded properly otherwise it acts as an antenna and picks up unwanted signals.

- More expensive than UTP.

Shielded Twisted Cable specifications according to types :

- Category 7 Shielded Cables: For 10G Base-T 10 Gigabit Ethernet, single cable support for multiple applications (such as Ethernet, CATV, analog voice, and VOIP), and future applications like 40G and 100G
- Category 7A Shielded Cables: For applications requiring higher frequencies up to 1GHz
- Category 6 Shielded Cables: Voice, T1 fractional, up to 100Base-T4 Fast Ethernet, and more.
- Category 6a Shielded Supra 10G Cables: Advanced Cat 6a shielded cables with a small O.D. to allow for more cables per conduit.
- Category 5e Shielded Cables: Tested from 1 to 400Mhz and component compliant to TIA Category 5e Cable requirements for applications ranging from voice and T1 fractional to 1000Base-T Gigabit Ethernet.

Shielded twisted pair applications :

One common use for **shielded twisted pair cables** is to use it in extreme cold situations. These **cables** are used for research where temperatures are below freezing and can sometimes be inhabitable for humans .

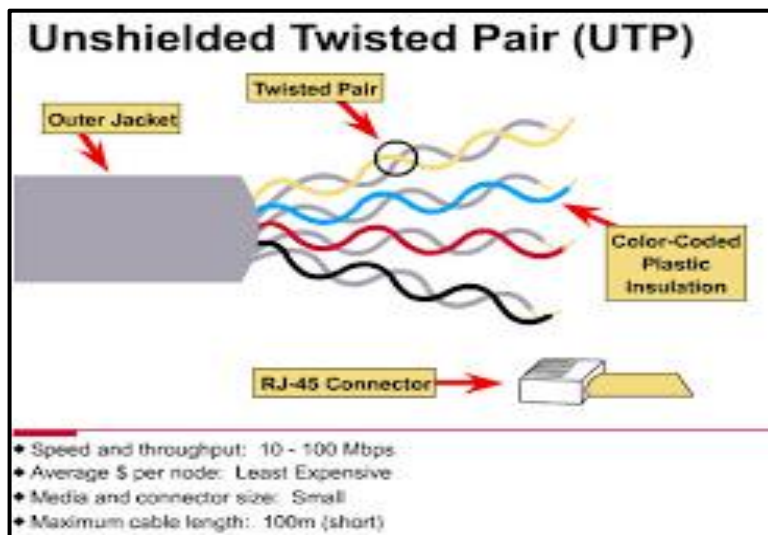
(2) Unshielded twisted pair :

Unshielded twisted pair (UTP) cables are widely used in the computer and telecommunications industry as Ethernet cables and telephone wires.

In an UTP cable, conductors which form a single circuit are twisted around each other in order to cancel out electromagnetic interference (EMI) from external sources. Unshielded means no additional shielding like meshes or aluminum foil, which add bulk, are used.

UTP cables are often groups of twisted pairs grouped together with color coded insulators, the number of which depends on the purpose.

Schematic representation of Unshielded twisted pair :



Advantages of unshielded twisted pair:

Mainly what are considered the disadvantages of the Shielded are the advantages of the unshielded.

For most networks, whether they be home or in an office, unshielded should be fit for purpose. They cancel out interference by being twisted, just as the shielded but at a way more precise level. So their advantages are:

- Cost - cheaper than the STP.
- Maintenance - As there is no foil to break and no grounding cable, there is less to break. This reduces the need to find a small tear in the foil.
- Installation - No need for extra special care to be taken off the cables during installation.
- Size - smaller and less sensitive makes it easier to squeeze them into tight spaces.
- Ubiquity - Use in most situations so there are more common.

Disadvantages of unshielded twisted pair :

Really the only disadvantage that UTP have over STP is when they would be used in an environment not fit for purpose. Meaning that they would be used in a situation where there is a lot of electromagnetic noise.

To Sum up, if there is a lot of electromagnetic noise that needs to be cancelled, then go with the STP cables, otherwise the UTP cables should suit your needs just fine.

Unshielded twisted pair specifications :

| UTP Categories - Copper Cable | | | | |
|-------------------------------|---------------|-------------|--------------|--|
| UTP Category | Data Rate | Max. Length | Cable Type | Application |
| CAT1 | Up to 1Mbps | - | Twisted Pair | Old Telephone Cable |
| CAT2 | Up to 4Mbps | - | Twisted Pair | Token Ring Networks |
| CAT3 | Up to 10Mbps | 100m | Twisted Pair | Token Ring & 10BASE-T Ethernet |
| CAT4 | Up to 16Mbps | 100m | Twisted Pair | Token Ring Networks |
| CAT5 | Up to 100Mbps | 100m | Twisted Pair | Ethernet, FastEthernet, Token Ring |
| CAT5e | Up to 1 Gbps | 100m | Twisted Pair | Ethernet, FastEthernet, Gigabit Ethernet |
| CAT6 | Up to 10Gbps | 100m | Twisted Pair | GigabitEthernet, 10G Ethernet (55 meters) |
| CAT6a | Up to 10Gbps | 100m | Twisted Pair | GigabitEthernet, 10G Ethernet (55 meters) |
| CAT7 | Up to 10Gbps | 100m | Twisted Pair | GigabitEthernet, 10G Ethernet (100 meters) |

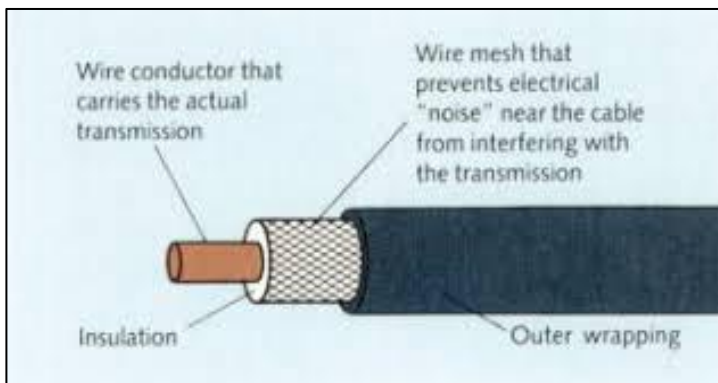
UTP Cable Applications :

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.

(3) Coaxial cable :

Coaxial cable is commonly used by cable operators, telephone companies, and internet providers around the world to convey data, video, and voice communications to customers. It has also been used extensively within homes.

It has been around for a long time as a technology (since the early 20th century) and has many singular advantages for reliable, accurate transmission.



Advantages of Coaxial Cable :

- It is less susceptible to noise or interference (EMI or RFI) compare to twisted pair cable.
- It supports high bandwidth signal transmission compare to twisted pair.
- It is easy to wire and easy to expand due to flexibility.

Disadvantages of coaxial :

- It is bulky.
- It is expensive to install for longer distances due to its thickness and stiffness.
- As single cable is used for signal transmission across the entire network, in case of failure in one cable the entire network will be down.

Specifications :

| Type | Mil Designation | Impedance (Ohms) | Dielectric | Outer Diameter (Inches) | Shield Construction | Capacitance (pF/ft) | Vmax (rms) |
|---------------|-----------------|------------------|------------|-------------------------|---------------------|---------------------|------------|
| RG-4/U | | 50 | PE | 0.226 | Braid | 31 | 1,900 |
| RG-5/U | | 52.5 | PE | 0.332 | Braid | 29 | 3,000 |
| RG-5A/B/U | | 50 | PE | 0.328 | Braid | 31 | 3,000 |
| RG-6/U | M17/2-RG6 | 76 | PE | 0.332 | Braid | 20 | 2,700 |
| RG-6A/U | M17/2-RG6 | 75 | PE | 0.332 | Braid | 21 | 2,700 |
| RG-8/U | | 52 | PE | 0.405 | Braid | 30 | 4,000 |
| 9914 (RG-8)/U | | 50 | PE | 0.403 | Braid+Foil | 25 | 300 |

Applications of coaxial :

Its **applications** include feedlines connecting radio transmitters and receivers to their antennas, computer network (e.g., Ethernet) connections, digital audio (S/PDIF), and distribution of **cable** television signals.

Types of Wireless Connections :[3]

Wireless transmission is a form of unguided media. Wireless communication involves no physical link established between two or more devices, communicating wirelessly. Wireless signals are spread over in the air and are received and interpreted by appropriate antennas.

When an antenna is attached to electrical circuit of a computer or wireless device, it converts the digital data into wireless signals and spread all over within its frequency range. The receptor on the other end receives these signals and converts them back to digital data.

(1) Radio Waves.

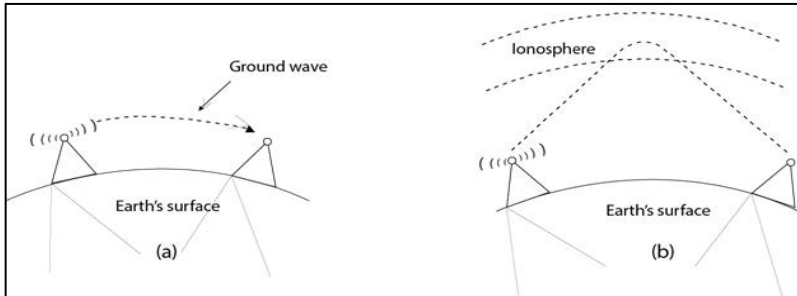
Radio waves are the electromagnetic waves that are transmitted in all the directions of free space.

Radio waves are omnidirectional, i.e., the signals are propagated in all the directions.

The range in frequencies of radio waves is from 3Khz to 1 khz.

In the case of radio waves, the sending and receiving antenna are not aligned, i.e., the wave sent by the sending antenna can be received by any receiving antenna.

An example of the radio wave is **FM radio**.



Applications Of Radio waves:

- A Radio wave is useful for multicasting when there is one sender and many receivers.
- An FM radio, television, cordless phones are examples of a radio wave.

Advantages Of Radio transmission:

- Radio transmission is mainly used for wide area networks and mobile cellular phones.
- Radio waves cover a large area, and they can penetrate the walls.
- Radio transmission provides a higher transmission rate.

(2) Infrared :

- An infrared transmission is a wireless technology used for communication over short ranges.
- The frequency of the infrared is in the range from 300 GHz to 400 THz.
- It is used for short-range communication such as data transfer between two cell phones, TV remote operation, data transfer between a computer and cell phone resides in the same closed area.

Characteristics Of Infrared:

- It supports high bandwidth, and hence the data rate will be very high.
- Infrared waves cannot penetrate the walls. Therefore, the infrared communication in one room cannot be interrupted by the nearby rooms.
- An infrared communication provides better security with minimum interference.
- Infrared communication is unreliable outside the building because the sun rays will interfere with the infrared waves.
- Example :



Range and specifications :

Different data rates use different modulation/coding schemes:

SIR: 9.6—115.2 kbit/s, asynchronous, RZI, UART-like, 3/16 pulse

MIR: 0.576—1.152 Mbit/s, RZI, 1/4 pulse, HDLC bit stuffing

FIR: 4 Mbit/s, 4PPM

VFIR: 16 Mbit/s, NRZ, HHH(1,13)

UFIR: 96 Mbit/s, NRZI, 8b/10b

GigaIR: 512 Mbit/s — 1 Gbit/s, NRZI, 2-ASK, 4-ASK, 8b/10b

Range:

standard: 1 m

low-power to low-power: 0.2 m

standard to low-power: 0.3 m.

The 10 GigaIR also define new usage models that supports higher link distances up to several meters.

(3) Bluetooth :[4]

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 managed by the Bluetooth Special Interest Group (SIG), which has more than 35,000 member companies in the areas of telecommunication, computing, networking, and consumer electronics. The IEEE standardized Bluetooth as **IEEE 802.15.1**, but no longer maintains the standard. The Bluetooth SIG oversees development of the specification, manages the qualification program, and protects the trademarks.

Applications :



A typical Bluetooth mobile phone headset

- Wireless control and communication between a mobile phone and a handsfree headset. This was one of the earliest applications to become popular.[29]
- Wireless control of and communication between a mobile phone and a Bluetooth compatible car stereo system (and sometimes between the SIM card and the car phone[30][31]).
- Wireless communication between a smartphone and a smart lock for unlocking doors.
- Wireless control of and communication with iOS and Android device phones, tablets and portable wireless speakers.

Range and Specifications :

| VERSIONS | | | | | | |
|---|---------------|---------------|---------------|---|---------------|---------------|
| Specifications | Bluetooth 1.1 | Bluetooth 1.2 | Bluetooth 2.0 | Bluetooth 2.1 plus EDR (enhanced data rate) | Bluetooth 3.0 | Bluetooth 4.0 |
| Voice dialing | Yes | Yes | Yes | Yes | Yes | Yes |
| Call mute | Yes | Yes | Yes | Yes | Yes | Yes |
| Last-number redial | Yes | Yes | Yes | Yes | Yes | Yes |
| Improved resistance to radio frequency interference | No | Yes | Yes | Yes | Yes | Yes |
| 10-meter range | Yes | Yes | Yes | Yes | Yes | Yes |
| 100-meter range | No | No | Yes | Yes | Yes | Yes |

| Device Class | Transmit Power | Intended Range |
|--------------|----------------|----------------------|
| Class 3 | 1 mW | Less than 10 meters |
| Class 2 | 2.5 mW | 10 meters, 33 feet |
| Class 1 | 100 mW | 100 meters, 328 feet |

(4) Zigbee :[5]

Zigbee is an IEEE 802.15.4-based specification for a suite of high-level communication protocols used to create personal area networks with small, low-power digital radios, such as for home automation, medical device data collection, and other low-power low-bandwidth needs, designed for small scale projects which need wireless connection. Hence, Zigbee is a low-power, low data rate, and close proximity (i.e., personal area) wireless ad hoc network.

The technology defined by the Zigbee specification is intended to be simpler and less expensive than other wireless personal area networks (WPANs), such as Bluetooth or more general wireless networking such as Wi-Fi. Applications include wireless light switches, home energy monitors, traffic management systems, and other consumer and industrial equipment that requires short-range low-rate wireless data transfer.

Its low power consumption limits transmission distances to 10–100 meters line-of-sight, depending on power output and environmental characteristics.[2] Zigbee devices can transmit data over

long distances by passing data through a mesh network of intermediate devices to reach more distant ones. Zigbee is typically used in low data rate applications that require long battery life and secure networking (Zigbee networks are secured by 128 bit symmetric encryption keys.) Zigbee has a defined rate of 250 kbit/s, best suited for intermittent data transmissions from a sensor or input device.

Zigbee



A Zigbee module

| | |
|-------------------------------|--|
| International standard | IEEE 802.15.4 |
| Developed by | Zigbee Alliance ^[1] |
| Industry | Industrial, scientific, medical, and IoT |
| Physical range | 10 to 20 meters |

(5) Li- Fi :[6]

Li-Fi (short for *light fidelity*) is wireless communication technology which utilizes light to transmit data and position between devices. The term was first introduced by Harald Haas during a 2011 TEDGlobal talk in Edinburgh.[1]

In technical terms, Li-Fi is a light communication system that is capable of transmitting data at high speeds over the visible light, ultraviolet, and infrared spectrums. In its present state, only LED lamps can be used for the transmission of visible light.[2]

In terms of its end use, the technology is similar to Wi-Fi -- the key technical difference being that Wi-Fi uses radio frequency to induce a voltage in an antenna to transmit data. Whereas Li-Fi uses the modulation of light intensity to transmit data. Li-Fi can theoretically transmit at speeds of up to 100 Gbit/s. Li-Fi's ability to safely function in areas otherwise susceptible to electromagnetic interference (e.g. aircraft cabins, hospitals, military) is an advantage.[3] The technology is being developed by several organizations across the globe.

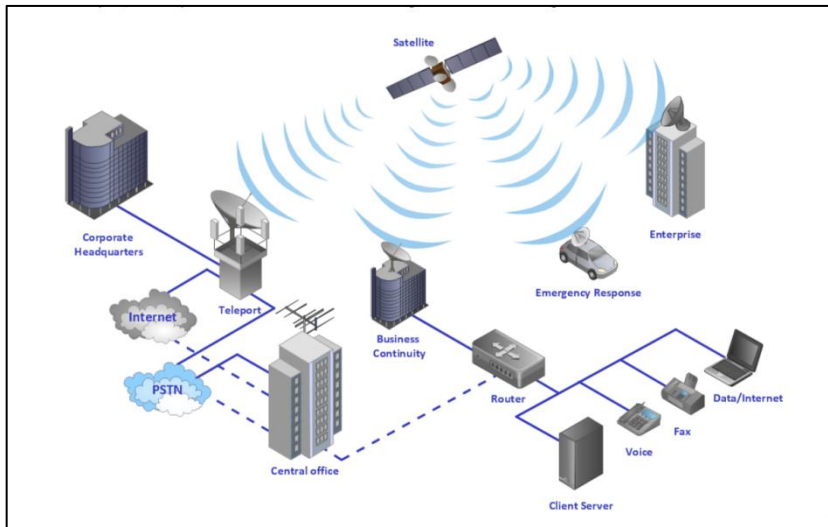
| S. No. | Parameter | Li-fi | Wi-fi |
|--------|-------------------------|------------------------------------|-------------------------------------|
| 1 | SPEED | > 1 GB/S | around 150 Mb/s |
| 2 | Medium of data transfer | Use light as carrier | Use radio spectrum |
| 3 | Spectrum range | Visible light has 10000 times more | Having less spectrum range than VLC |
| 4 | Cost | Cheaper | Expensive |
| 5 | Network topology | Point to point | Point to point |
| 6 | Operating frequency | Hundreds of Tera Hz | 2.4 GHz |

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Use of wired and wireless media in different network architectures :(7)

(1) Persoal Area Network(PAN) :

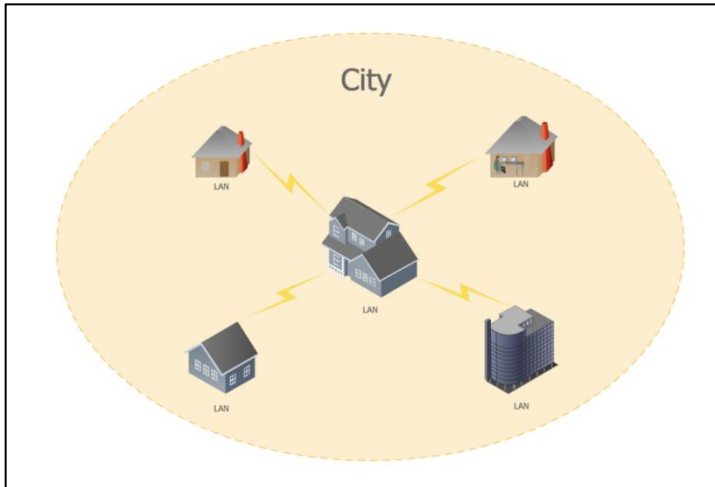
Personal area network (PAN) is a network organized on a limited area and used for data transmission between various personal devices, such as computers, tablets, laptops, telephones, different digital and mobile devices, etc. and also for connecting to higher level network and Internet. PAN is used to manage the interconnections of IT devices which surround a single user and generally contains such appliances, as cordless mice, keyboard, phone, and Bluetooth handsets. PANs can be wired with computer buses, or wirelessly connected to the Internet using such network technologies as Bluetooth, Z-Wave, ZigBee, IrDa, UWB, Body Area Network. PANs have a lot of pros and cons, they are expedient, lucrative and handy, but sometimes have bad connection with other networks on the same radio bands, Bluetooth has distance limits and slow data transfer speed, but is comparatively safe.



(2) Metropolitan Area Network(MAN) :

A Metropolitan Area Network (MAN) is a great computer network located on the large geographical area or region. It is a network bigger than Local Area Network (LAN), but territorially smaller than Wide Area Network (WAN), its diameter usually ranges from 5 to 50 kilometers. MAN usually includes several buildings or even the whole city (metropolis). It is based on high data rate compounds using the fiber channels and other digital data transmission channels. MAN includes a lot of communicating devices, for its construction are used multiple routers, switches and hubs. MAN can combine together several Local Area Networks or Campus Area Networks located in different buildings within a city and provides the Internet connectivity for them. Solutions included to Computer and Networks Area

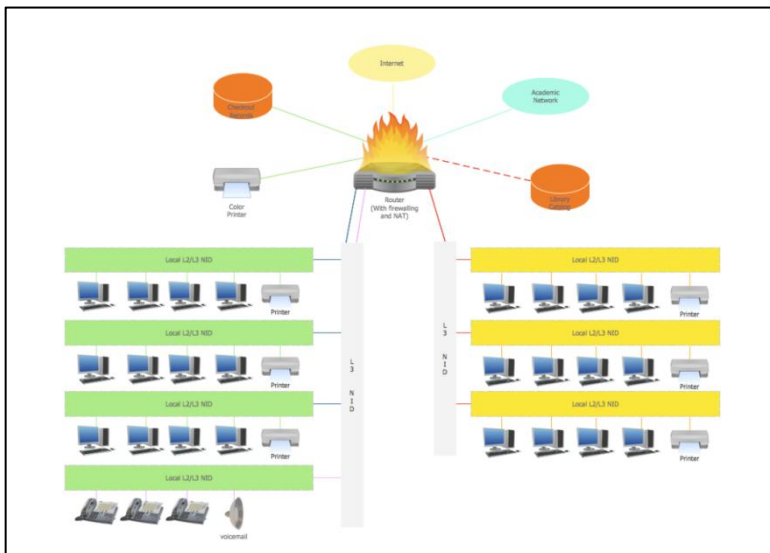
for ConceptDraw Solution Park are the real godsend for those who want design Computer Network Diagrams, and among others the Metropolitan Area Network Diagrams. They offer the libraries with ready-to-use vector design elements, professional-looking examples, samples and templates.



(3) Campus Area Network (CAN):

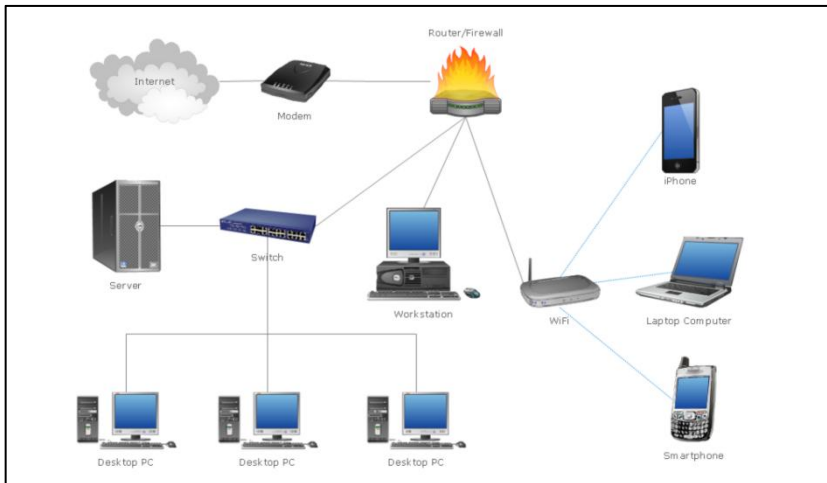
Campus Area Network (CAN) is a computer network which provides wireless access to the Internet or LAN for the users located in two or more buildings on the limited geographical area, or in the open space surrounding these buildings. Campus Area Network is usually set in campus of a university or college, but the same kind of planning and design can be

applied for other purposes, for enterprises, office buildings, military bases, industrial complexes, public places like supermarkets, entertainment centers, etc. Another form of temporary CAN can exist during some special events such as rallies, music festivals. The elementary Campus Area Network can also arise spontaneously, due to the distance of spread the radio signals from the access points that are not limited by buildings walls. It is also sensible to have additional access points for the larger and more complex CANs, located at specially places chosen for serving clients.



(4) Local Area Network(LAN) :

Local Area Network (LAN) is a network which consists of computers and peripheral devices connected each other and to the local domain server, and covers a little territory or small number of buildings, such as home, school, laboratory, office, etc. LAN serves for few hundreds of users. It includes many cables and wires, and demands to design previously a Network diagram. All local area network devices can use the shared printers and disk storage. ConceptDraw DIAGRAM is a perfect network diagramming software with examples of LAN Diagrams, templates and predesigned vector objects. ConceptDraw DIAGRAM is the ideal choice for network engineers and network designers who need to draw fast and easy Local Area Network Diagrams, for IT specialists, developers and other IT professionals which need to visualize the communication schemes of LAN and visually document the LAN's physical structure and arrangement in houses, offices and other buildings



References :

(1)https://en.wikipedia.org/wiki/Physical_layer

(2)<https://study.com/academy/lesson/physical-layer-of-the-osi-model-definition-components-media.html>

(3)https://www.tutorialspoint.com/data_communication_computer_network/wireless_transmission.htm

(4)https://www.tutorialspoint.com/wireless_communication/wireless_communication_bluetooth.htm

(5) <https://en.wikipedia.org/wiki/Zigbee>

(6)<https://en.wikipedia.org/wiki/Li-Fi>

(7)<https://www.conceptdraw.com/examples/wired-personal-area-network>

Conclusion :

Thus, understood different types of networks and architectures, difference between them and its applications based on range and specifications.

