Experiment 1

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Aim : Study of different types of physical layer wired/wireless connections

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[1] 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.

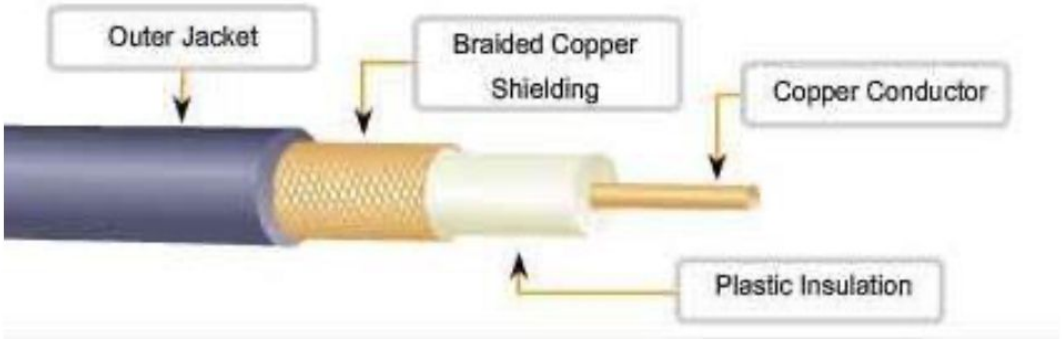
Functions of Physical Layer

1. Representation of Bits: Data in this layer consists of stream of bits. The bits must be encoded into signals for transmission. It defines the type of encoding i.e. how 0's and 1's are changed to signal.
2. Data Rate: This layer defines the rate of transmission which is the number of bits per second.
3. Synchronization: It deals with the synchronization of the transmitter and receiver. The sender and receiver are synchronized at bit level.
4. Interface: The physical layer defines the transmission interface between devices and transmission medium.
5. Line Configuration: This layer connects devices with the medium: Point to Point configuration and Multipoint configuration.
6. Topologies: Devices must be connected using the following topologies: Mesh, Star, Ring and Bus.
7. Transmission Modes: Physical Layer defines the direction of transmission between two devices: Simplex, Half Duplex, Full Duplex.
8. Deals with baseband and broadband transmission.

Types of Physical Layers(Wired):

Coaxial

Coaxial cable consists of a copper conductor surrounded by a layer of flexible insulation, as shown in the figure. Over this insulating material is a woven copper braid, or metallic foil, that acts as the second wire in the circuit and as a shield for the inner conductor. This second layer, or shield, also reduces the amount of outside electromagnetic interference. Covering the shield is the cable jacket. All the elements of the coaxial cable encircle the center conductor. Because they all share the same axis, this construction is called coaxial, or coax for short. Coax cables are used to attach antennas to wireless devices. This combined use of fiber and coax is referred to as hybrid fiber coax (HFC). In the past, coaxial cable was used in Ethernet installations. Today UTP offers lower costs and higher bandwidth than coaxial and has replaced it as the standard for all Ethernet installations.



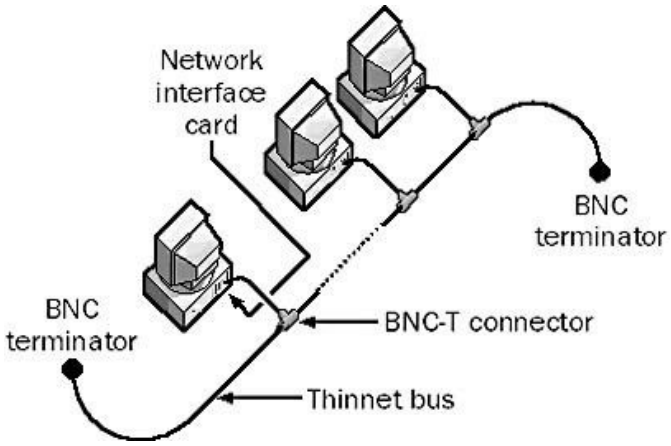
1. **10BASE2** - is a variant of Ethernet (cheapernet) that uses thin coaxial cable terminated with BNC connectors to build a local area network.
   The name 10BASE2 is derived from several characteristics of the physical medium. The 10 comes from the transmission speed of 10 Mbit/s. The BASE stands for baseband signalling, and the 2 for a maximum segment length approaching 200 m.

   Range: The actual range is 185m.

   Modulation: 10 Mbit/s Ethernet uses Manchester coding. A binary zero is indicated by a low-to-high transition in the middle of the bit period and a binary one is indicated by a high-to-low transition in the middle of the bit period. Manchester coding allows the clock to be recovered from the signal. However, the additional transitions associated with it double the signal bandwidth.

Network Design: 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. In a 10BASE2 network, each stretch of cable is connected to the transceiver (which is usually built into the network adaptor) using a BNC T-connector, with one stretch connected to each female connector of the T. The T-connector must be plugged directly into the network adaptor with no cable in between.

When wiring a 10BASE2 network, special care has to be taken to ensure that cables are properly connected to all T-connectors. Bad contacts or shorts are especially difficult to diagnose. A failure at any point of the network cabling tends to prevent all communications.

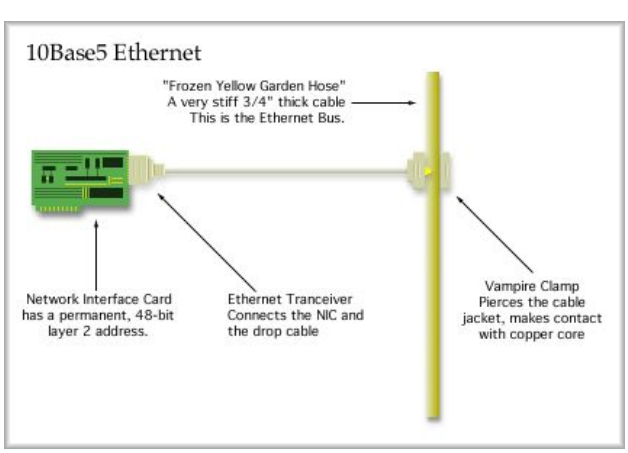


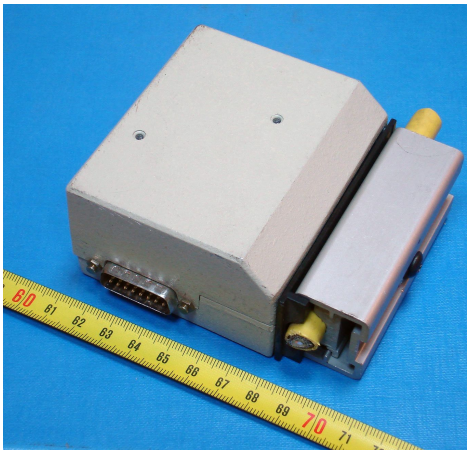
Schematic of 10BASE-2

2. **10BASE5** - (also known as thick Ethernet or thicknet) was the first commercially available variant of Ethernet. The technology was standardized in 1982 as IEEE 802.3. 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. The system is difficult to install and maintain.

   Range: The actual range is 500m.

   Modulation: It uses Manchester coding.





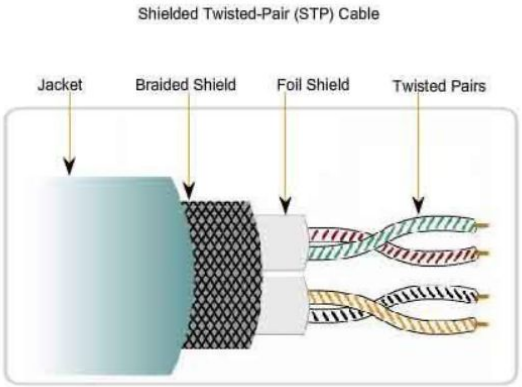
Schematic of 10BASE-5

Twisted Pair

Shielded Twisted Pair:

Another type of cabling used in networking is shielded twisted-pair (STP). As shown in the figure, STP uses two pairs of wires that are wrapped in an overall metallic braid or foil. STP cable shields the entire bundle of wires within the cable as well as the individual wire pairs.

STP provides better noise protection than UTP cabling, however at a significantly higher price. For many years, STP was the cabling structure specified for use in Token Ring network installations. With the use of Token Ring declining, the demand for shielded twisted-pair cabling has also waned. The new 10 GB standard for Ethernet has a provision for the use of STP cabling. This may provide a renewed interest in shielded twisted-pair cabling.

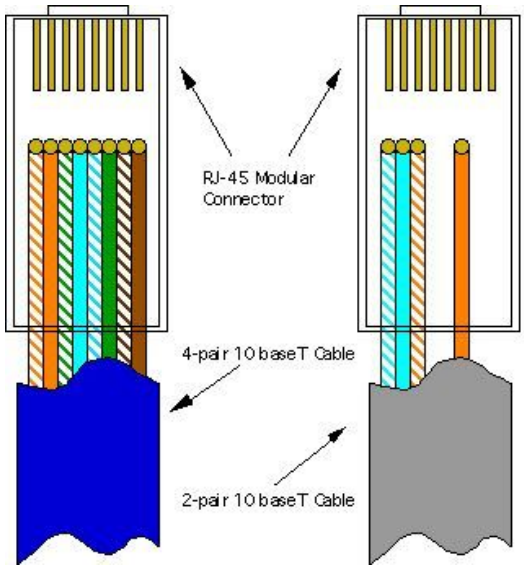


3. **10BASE-T** - The common names for the standards derive from aspects of the physical media. The leading number (10 in 10BASE-T) refers to the transmission speed in Mbit/s. BASE denotes that baseband transmission is used. The T designates twisted pair cable. Where there are several standards for the same transmission speed, they are distinguished by a letter or digit following the T, such as TX or T4, referring to the encoding method and number of lanes.[8]

   Range: The range is 100m.

   Scalability: It is scalable in LAN architecture.

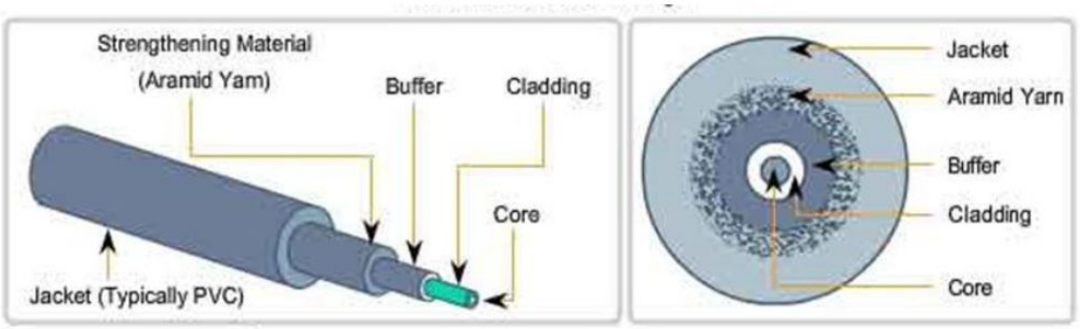
   The 10BASE-T is the legacy version and further generations of it specifying their speed, range are given below:-
   100BASE-T1: Speed of 100 Mbit/s and range of 15m.
   100BASE-TX: Speed of 100 Mbit/s and range of 100m.
   1000BASE-T: Speed of 1000 Mbit/s and range of 100m.
   2.5GBASE-T: Speed of 2500 Mbit/s and range of 100m.
   5GBASE-T: Speed of 5000 Mbit/s and range of 100m.
   10GBASE-T: Speed of 10000 Mbit/s and range of 100m.
   20GBASE-T: Speed of 20000 Mbit/s and range of 30m.
   40GBASE-T: Speed of 40000 Mbit/s and range of 30m.



Schematic of 10BASE-T

Fiber Optic Cable

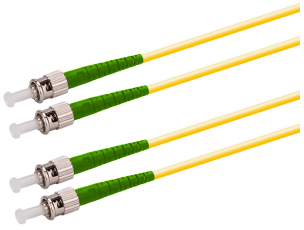
Fiber-optic cabling uses either glass or plastic fibers to guide light impulses from source to destination. The bits are encoded on the fiber as light impulses. Optical fiber cabling is capable of very large raw data bandwidth rates. Most current transmission standards have yet to approach the potential bandwidth of this media. At present, in most enterprise environments, optical fiber is primarily used as backbone cabling for high-traffic point-to-point connections between data distribution facilities and for the interconnection of buildings in multi-building campuses. Because optical fiber does not conduct electricity and has low signal loss, it is well suited for these uses.



4. **<u>10BASE-F:</u>** Classic Ethernet is a family of 10 Mbit/s Ethernet standards, which is the first generation of Ethernet standards. In 10BASE-X, the 10 represents its maximum throughput of 10 Mbit/s, BASE indicates its use of baseband transmission, and X indicates the type of medium used.

   <u>Range:</u> The range is 2000m.

   <u>Scalability:</u> It is scalable in CAN architecture.



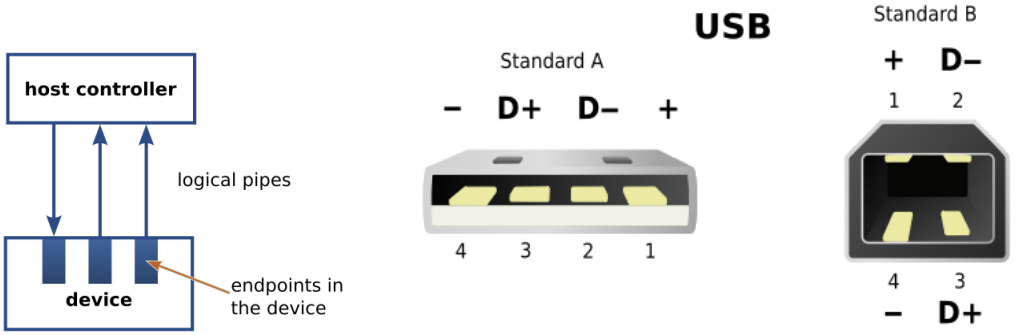
Ex: 10BASE-FL,10BASE-FB,10BASE-FP.

5. **100BASE-FX:** It uses multimode optical fibre. Maximum length is 400 meters for half-duplex connections (to ensure collisions are detected) or 2 kilometers for full-duplex.
6. **100BASE-BX10:** It uses single mode optical fibre. Range is 10 kilometers for full-duplex only.

USB

Universal Serial Bus (USB) is an industry standard that establishes specifications for cables and connectors and protocols for connection, communication and power supply (interfacing) between computers, peripherals and other computers.[3] A broad variety of USB hardware exists, including several different connectors, of which USB-C is the most recent.

USB Version	Year of Release	Data Rate
1.0	1996	1.5 Mbit/s
1.1	1998	1.5 - 12 Mbit/s
2.0	2001	1.5 - 480 Mbit/s
3.0	2011	5 Gbit/s
3.1	2014	10 Gbit/s
3.2	2017	20 Gbit/s
4.0	2019	40 Gbit/s



Schematic of USB

Wireless Media:-

A **wireless network** is a computer network that uses wireless data connections between network nodes.

Wireless networking is a method by which homes, telecommunications networks and business installations avoid the costly process of introducing cables into a building, or as a connection between various equipment locations. admin telecommunications networks are generally implemented and administered using radio communication. This implementation takes place at the physical level (layer) of the OSI model network structure.

Examples of wireless networks include cell phone networks, wireless local area networks (WLANs), wireless sensor networks, satellite communication networks, and terrestrial microwave networks.

Different Types of Wireless Networks are:

Wireless PAN

Wireless personal area networks (WPANs) connect devices within a relatively small area, that is generally within a person's reach. For example, both Bluetooth radio and invisible infrared light provides a WPAN for interconnecting a headset to a laptop. Wi-Fi PANs are becoming commonplace (2010) as equipment designers start to integrate Wi-Fi into a variety of consumer electronic devices. Intel "My WiFi" and Windows 7 "virtual Wi-Fi" capabilities have made Wi-Fi PANs simpler and easier to set up and configure.

Wireless HAN

A HAN, or home area network, is a network connecting devices within a home. These networks are a type of LAN. All the devices inside the household, including computers, smartphones, game consoles, televisions, and home assistants that are connected to the router are a part of the HAN.

Wireless CAN

A CAN, or campus area network, usually comprises several LANs. They cover a campus, connecting several buildings to the main firewall. A university could use a CAN, as could a corporate headquarters.

Wireless ad hoc network

A wireless ad hoc network, also known as a wireless mesh network or mobile ad hoc network (MANET), is a wireless network made up of radio nodes organized in a mesh topology. Each node forwards messages on behalf of the other nodes and each node performs routing. Ad hoc networks can "self-heal", automatically re-routing around a

node that has lost power. Various network layer protocols are needed to realize ad hoc mobile networks, such as Distance Sequenced Distance Vector routing, Associativity-Based Routing, Ad hoc on-demand Distance Vector routing, and Dynamic source routing.

Wireless WAN

Wireless wide area networks are wireless networks that typically cover large areas, such as between neighbouring towns and cities, or city and suburb. These networks can be used to connect branch offices of business or as a public Internet access system. The wireless connections between access points are usually point to point microwave links using parabolic dishes on the 2.4 GHz and 5.8Ghz band, rather than omnidirectional antennas used with smaller networks. A typical system contains base station gateways, access points and wireless bridging relays. Other configurations are mesh systems where each access point acts as a relay also. When combined with renewable energy systems such as photovoltaic solar panels or wind systems they can be stand alone systems.

Major Types of wireless networks are:

Standard IEEE 802.11 - Commonly referred to as Wi-Fi, is a Wireless LAN (WLAN) technology that uses a contention or non-deterministic system with a Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) media access process.

Standard IEEE 802.15 - Wireless Personal Area Network (WPAN) standard, commonly known as "Bluetooth", uses a device pairing process to communicate over distances from 1 to 100 meters.

Standard IEEE 802.16 - Commonly known as WiMAX (Worldwide Interoperability for Microwave Access), uses a point-to-multipoint topology to provide wireless broadband access.

Global System for Mobile Communications (GSM) - Includes Physical layer specifications that enable the implementation of the Layer 2 General Packet Radio Service (GPRS) protocol to provide data transfer over mobile cellular telephony

Networks.

Wireless local area network (WLAN) : A wireless LAN (WLAN) is a wireless computer network that links two or more devices using wireless communication to form a local area network (LAN) within a limited area such as a home, school, computer laboratory, campus, or office building. This gives users the ability to move around within the area and remain connected to the network. Through a gateway, a WLAN can also provide a connection to the wider Internet.Most modern WLANs are based on IEEE 802.11 standards and are marketed under the Wi-Fi brand name.Wireless LANs have become popular for use in the

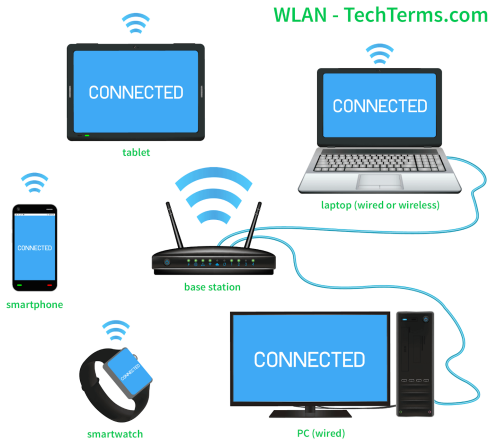
home, due to their ease of installation and use. They are also popular in commercial properties that offer wireless access to their employees and customers.

The different types of wireless network standards are:-

IEEE 802.11 network PHY standards [hide]

Frequency range, or type	PHY	Protocol	Release date[12]	Frequency (GHz)	Bandwidth (MHz)	Stream data rate[13] (Mbit/s)	Allowable MIMO streams	Modulation	Approximate range[citation needed] Indoor	Outdoor
1–6 GHz	DSSS/FHSS[14]	802.11-1997	Jun 1997	2.4	22	1, 2	N/A	DSSS, FHSS	20 m (66 ft)	100 m (330 ft)
	HR-DSSS[14]	802.11b	Sep 1999	2.4	22	1, 2, 5.5, 11	N/A	DSSS	35 m (115 ft)	140 m (460 ft)
	OFDM	802.11a	Sep 1999	5	5/10/20	6, 9, 12, 18, 24, 36, 48, 54 (for 20 MHz bandwidth, divide by 2 and 4 for 10 and 5 MHz)	N/A	OFDM	35 m (115 ft)	120 m (390 ft)
		802.11j	Nov 2004	4.9/5.0[D][15] [failed verification]					?	?
		802.11p	Jul 2010	5.9					?	1,000 m (3,300 ft)[16]
		802.11y	Nov 2008	3.7[A]					?	5,000 m (16,000 ft)[A]
	ERP-OFDM(, etc.)	802.11g	Jun 2003	2.4					38 m (125 ft)	140 m (460 ft)
	HT-OFDM[17]	802.11n	Oct 2009	2.4/5	20	Up to 288.8[B]	4	MIMO-OFDM	70 m (230 ft)	250 m (820 ft)[18] [failed verification]
					40	Up to 600[B]				
	VHT-OFDM[17]	802.11ac	Dec 2013	5	20	Up to 346.8[B]	8	MIMO-OFDM	35 m (115 ft)[19]	?
					40	Up to 800[B]				
					80	Up to 1733.2[B]				
					160	Up to 3466.8[B]				
	HE-OFDM	802.11ax	September 2019[20]	2.4/5/6	20	Up to 1147[F]	8	MIMO-OFDM	30 m (98 ft)	120 m (390 ft) [G]
					40	Up to 2294[F]				
					80	Up to 4804[F]				
					80+80	Up to 9608[F]				
mmWave	DMG[21]	802.11ad	Dec 2012	60	2,160	Up to 6,757[22] (6.7 Gbit/s)	N/A	OFDM, single carrier, low-power single carrier	3.3 m (11 ft)[23]	?
		802.11aj	Apr 2018	45/60[C]	540/1,080[24]	Up to 15,000[25] (15 Gbit/s)	4[26]	OFDM, single carrier[26]	?	?
	EDMG[27]	802.11ay	Est. May 2020	60	8000	Up to 20,000 (20 Gbit/s)[28]	4	OFDM, single carrier	10 m (33 ft)	100 m (328 ft)
Sub-1 GHz IoT	TVHT[29]	802.11af	Feb 2014	0.054–0.79	6–8	Up to 568.9[30]	4	MIMO-OFDM	?	?
	S1G[29]	802.11ah	Dec 2016	0.7/0.8/0.9	1–16	Up to 8.67 (@2 MHz)[31]	4		?	?
2.4 GHz, 5 GHz	WUR	802.11ba[E]	Est. Sep 2020	2.4/5	4.06	0.0625, 0.25 (62.5 kbit/s, 250 kbit/s)	N/A	OOK (Multi-carrier OOK)	?	?
Light (Li-Fi)	IR	802.11-1997	Jun 1997	?	?	1, 2	N/A	PPM	?	?
	?	802.11bb	Est. Jul 2021	60000-790000	?	?	N/A	?	?	?

Schematic of a WLAN



1. **<u>Wireless Wide Area Network (WWAN) :</u>** 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. It is sometimes referred as Mobile Broadband. These technologies are offered regionally, nationwide, or even globally and are provided by a wireless service provider.Since radio communications systems do not provide a physically secure connection path, WWANs typically incorporate encryption and authentication methods to make them more secure.

   Latest use of this WWAN technology is in the 5G technology.

   5G networks are digital cellular networks, in which the service area covered by providers is divided into small geographical areas called cells. Analog signals representing sounds and images are digitized in the telephone, converted by an analog-to-digital converter and transmitted as a stream of bits. All the 5G wireless devices in a cell communicate by radio waves with a local antenna array and low power automated transceiver (transmitter and receiver) in the cell, over frequency channels assigned by the transceiver from a pool of frequencies that are reused in other cells. The local antennas are connected with the telephone network and the Internet by a high-bandwidth optical fiber or wireless backhaul connection. As in other cell networks, a mobile device crossing from one cell to another is automatically "handed off" seamlessly to the new cell. 5G can support up to a million devices per square kilometer.

   <u>Range:</u>

Cell types		Deployment environment	Max. number of users	Output power (mW)	Max. distance from base station
5G NR FR2	Femtocell	Homes, businesses	Home: 4–8 Businesses: 16–32	indoors: 10–100 outdoors: 200–1000	10s of meters
	Pico cell	Public areas like shopping malls, airports, train stations, skyscrapers	64 to 128	indoors: 100–250 outdoors: 1000–5000	10s of meters
	Micro cell	Urban areas to fill coverage gaps	128 to 256	outdoors: 5000−10000	few hundreds of meters
	Metro cell	Urban areas to provide additional capacity	more than 250	outdoors: 10000−20000	hundreds of meters
Wi-Fi (for comparison)		Homes, businesses	less than 50	indoors: 20–100 outdoors: 200–1000	few 10s of meters

Modulation :

New radio frequencies

The air interface defined by 3GPP for 5G is known as New Radio (NR), and the specification is subdivided into two frequency bands, FR1 (below 6 GHz) and FR2 (mmWave), each with different capabilities.

Frequency range 1 (< 6 GHz)

The maximum channel bandwidth defined for FR1 is 100 MHz, due to the scarcity of continuous spectrum in this crowded frequency range. The band most widely being used for 5G in this range is 3.3–4.2 GHz.

Frequency range 2 (> 24 GHz)

The minimum channel bandwidth defined for FR2 is 50 MHz and the maximum is 400 MHz, with two-channel aggregation supported in 3GPP Release 15. The higher the frequency, the greater the ability to support high data-transfer speeds.

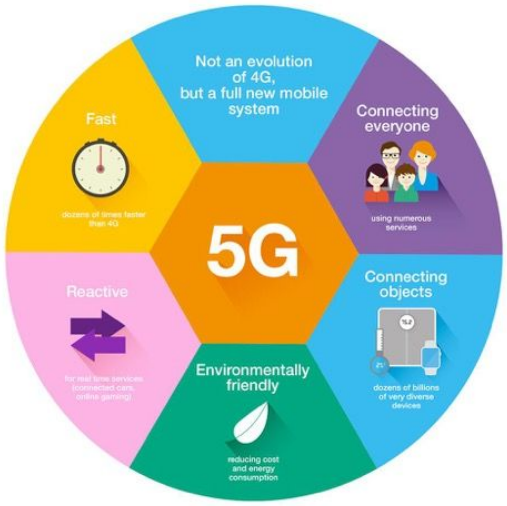
FR2 coverage

5G in the 24 GHz range or above use higher frequencies than 4G, and as a result, some 5G signals are not capable of traveling large distances (over a few hundred meters), unlike 4G or lower frequency 5G signals (sub 6 GHz). This requires placing 5G base stations every few hundred meters in order to use higher frequency bands.

Scalability:

The ITU-R has defined three main application areas for the enhanced capabilities of 5G. They are Enhanced Mobile Broadband (eMBB), Ultra Reliable Low Latency Communications (URLLC), and Massive Machine Type Communications (mMTC). Only eMBB is deployed in 2020; URLLC and mMTC are several years away in most locations. Enhanced Mobile Broadband (eMBB) uses 5G as a progression from 4G LTE mobile broadband services, with faster connections, higher throughput, and more capacity. Ultra-Reliable Low-Latency Communications (URLLC) refer to using the network for mission critical applications that require uninterrupted and robust data exchange. Massive Machine-Type Communications (mMTC) would be used to

connect to a large number of devices, 5G technology will connect some of the 50 billion connected IoT devices. Most cars will have a 4G or 5G cellular connection for many services. Autonomous cars do not require 5G, as they have to be able to operate where they do not have a network connection. While remote surgeries have been performed over 5G, most remote surgery will be performed in facilities with a fiber connection, usually faster and more reliable than any wireless connection.



Conclusion and References: With your help and guidance I was able to have a deeper understanding of various types of physical layers in Networking. The above mentioned information has been taken from the following websites:-

www.wikipedia.com

www.stackoverflow.com

https://www.google.com/search?q=schematic+10base2&rlz=1C5CHFA_enIN876IN876&oq=schematic+10BASE-2&aqs=chrome.1.69i57j33.10202j1j8&sourceid=chrome&ie=UTF-8

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