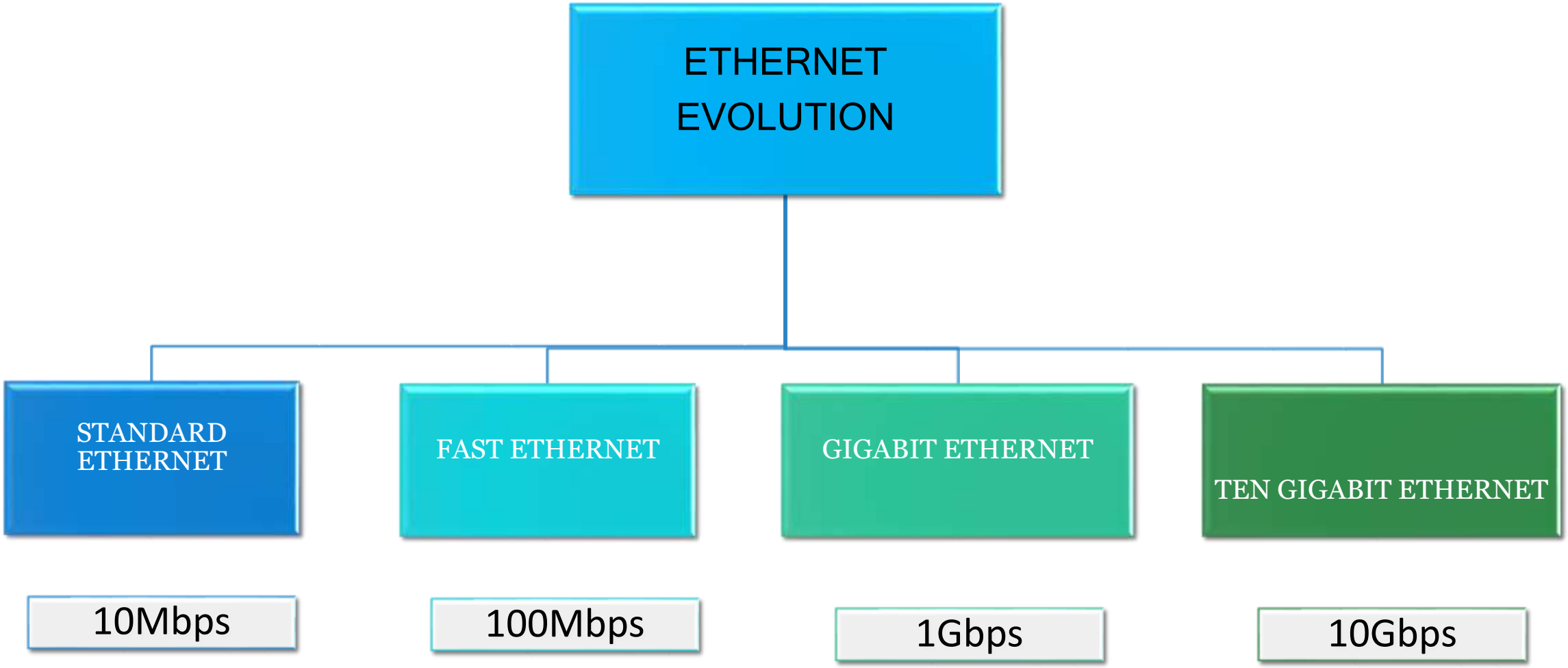
ETHERNET

- FAST ETHERNET
- GIGABIT ETHERNET

What is Ethernet?

Ethernet is a family of computer networking technologies for local area networks (LANs) and metropolitan area networks (MANs). It was commercially introduced in 1980 and first standardized in 1983 as IEEE 802.3,[1] and has since been refined to support higher bit rates and longer link distances.

Over time, Ethernet has largely replaced competing wired LAN technologies such as token ring, FDDI, and ARCNET


ETHERNET EVOLUTION
STANDARD ETHERNET
FAST ETHERNET
GIGABIT ETHERNET
TEN GIGABIT ETHERNET
10Mbps
100Mbps
1Gbps
10Gbps

IEEE STANDARD FOR LANs

LLC : Logical link control

MAC :Media access control

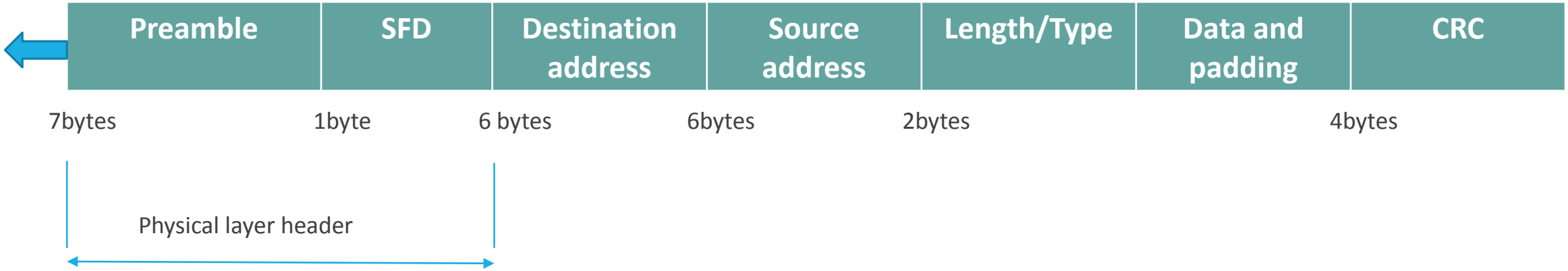
Upper Layers		Upper layers		
Data link layer			LLC	
		Ethernet MAC	Token Ring MAC	Token Bus MAC	…
Physical Layer		Ethernet Physical Layers (several)	Token Ring Physical Layer	Token Bus Physical Layer	…
Transmission medium (OSI/Internet model)			Transmission Medium (IEEE STANDARD)	

MAC Sublayer : In standard Ethernet , the MAC sublayer ,governs the operation of the access method . And it also frames data received from the upper layer and passes them to the physical layer.

FRAME FORMAT

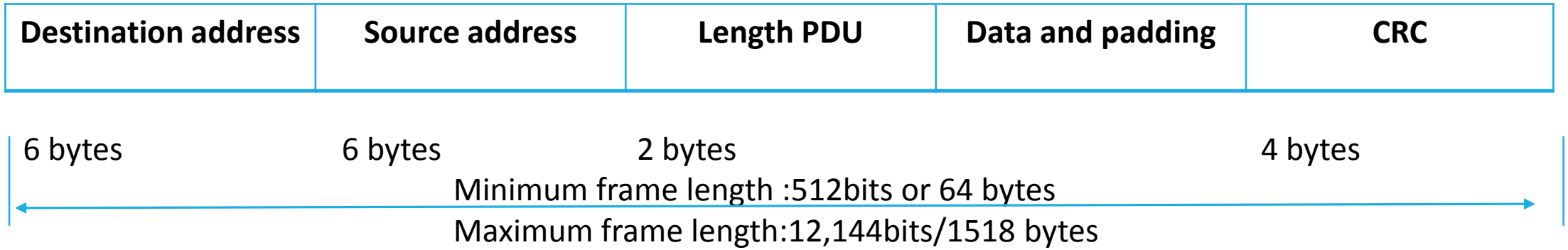
The Ethernet frames contains seven fields : preamble ,SFD ,DA ,SA ,length or type of protocol data unit(PDU),upper-layer data ,the CRC . Ethernet does not provide any mechanism for acknowledging received frames , making it what is known as an unreliable medium . Acknowledgement must be implemented at the higher layers . The format of the MAC frame is shown in fig.

802.3 MAC frame: **Preamble:56 bits if alternating 1s and 0sSFD:Strat frame delimiter ,flag(10101011)**



- PREAMBLE:The first field of the 802.3 frame contains 7 bytes(56bits)of alternating 0s and 1s that alerts the receiving system to coming frame and enables it to synchronize its input timing.
- START FRAME DELIMITER(SFD):The second field (1byte:10101011)signals the beginning of the frame . The SFD warns the station that this is the last chance for synchronization . The last 2 bits is11 and alerts the receive that the next field is the destination address.
- DESTINATION ADDRESS(DA):The DA field is 6bytes and contain the physical address of the destination station to receive the packet
- SOURCE ADDRESS : The SA field is also 6 bytes and contains the physical address of the sender of the packet.
- LENGTH/TYPE : This field is defined as a type field or length field.Theoriginal Ethernet used this field as the type field to define the upper –layer protocol using the MAC frame.
- DATA : This field carries data encapsulated from the upper –layer protocols.It is a minimum of 46 and a maximum of 1500 bytes.
- CRC : The last filed contains error detection information,in this case a CRC-32.

FRAME LENGTH : Ethernet has imposed restriction on both the minimum and maximum lengths of a frame , as shown below



REQUIREMENT OF MIN/MAX LENGTH:

- The minimum length is required for the correct operation of CSMA/CD.
- The maximum length is used to reduce the size of the buffer.
- It also prevents one station from monopolizing the shared medium.

ADDRESSING : Each station on a Ethernet network(such as PC ,workstation or printer) has its own network interface card(NIC).The NIC fits inside the station and provides the station with a 6-byte physical address . The Ethernet address is 6bytes(48 bits)written in hexadecimal notation , with a colon between the bytes.

Example: 06:01:02:01:2C:4B

6bytes =12 hex digits=48 bits

UNICAST AND MULTICAST ADDRESSES

- The least significant bit of the first byte defines the type of address . If the bit is 0 ,the address is unicast ; otherwise , it is multicast.
- A unicast address defines only one recipient ; the relationship between the sender and the receiver is one-to-one.
- A multicast address defines a group of addresses ; the relationship between the sender and the receiver is one-to-many.
- The broadcast destination address is a special case of the multicast address in which all bits are 1s.

ACCESS METHOD:CSMA/CD

Standard Ethernet uses 1-persistent CSMA/CD

SLOT TIME:

Slot time=round-trip time + time required to send the jam sequence

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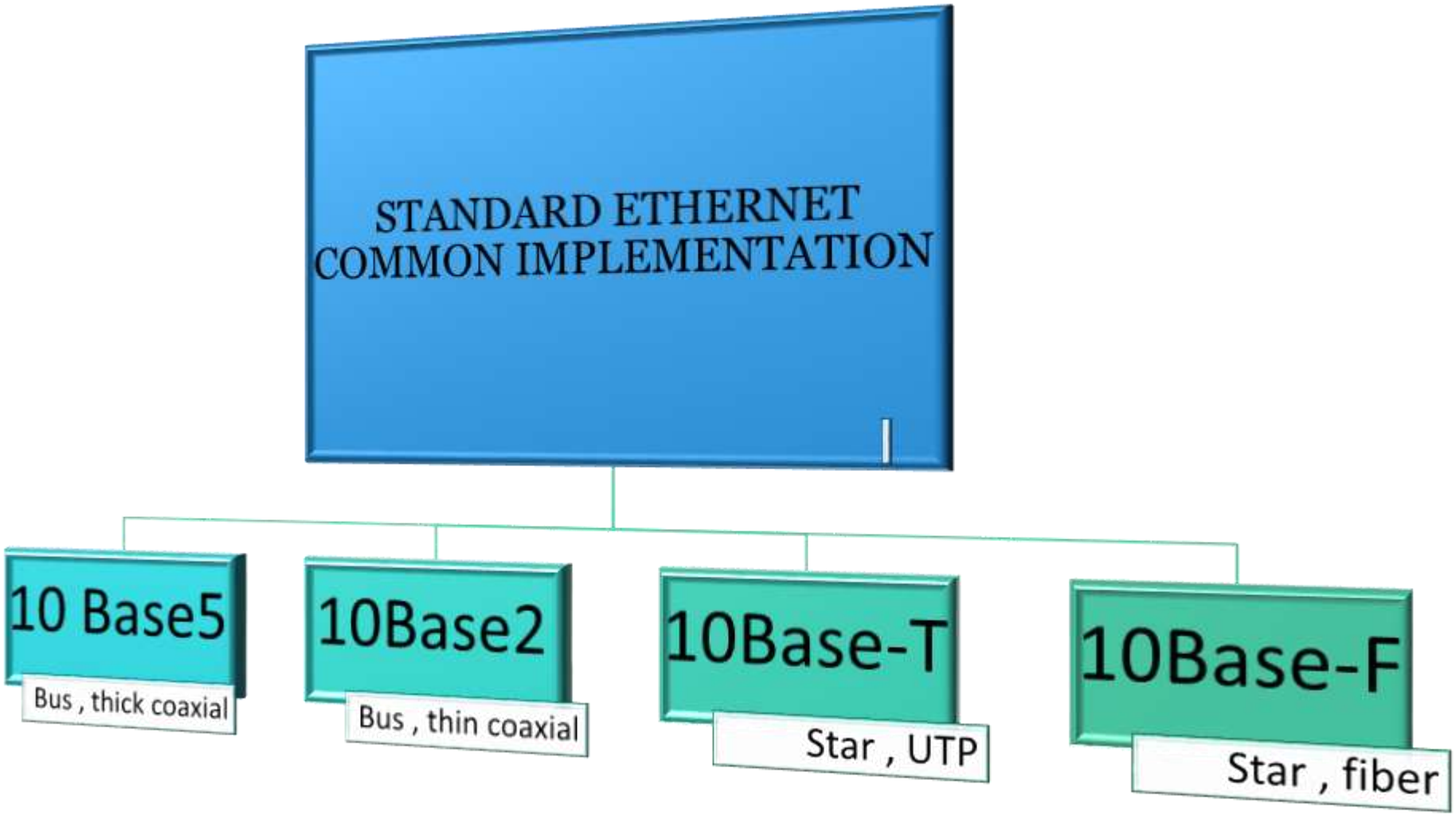
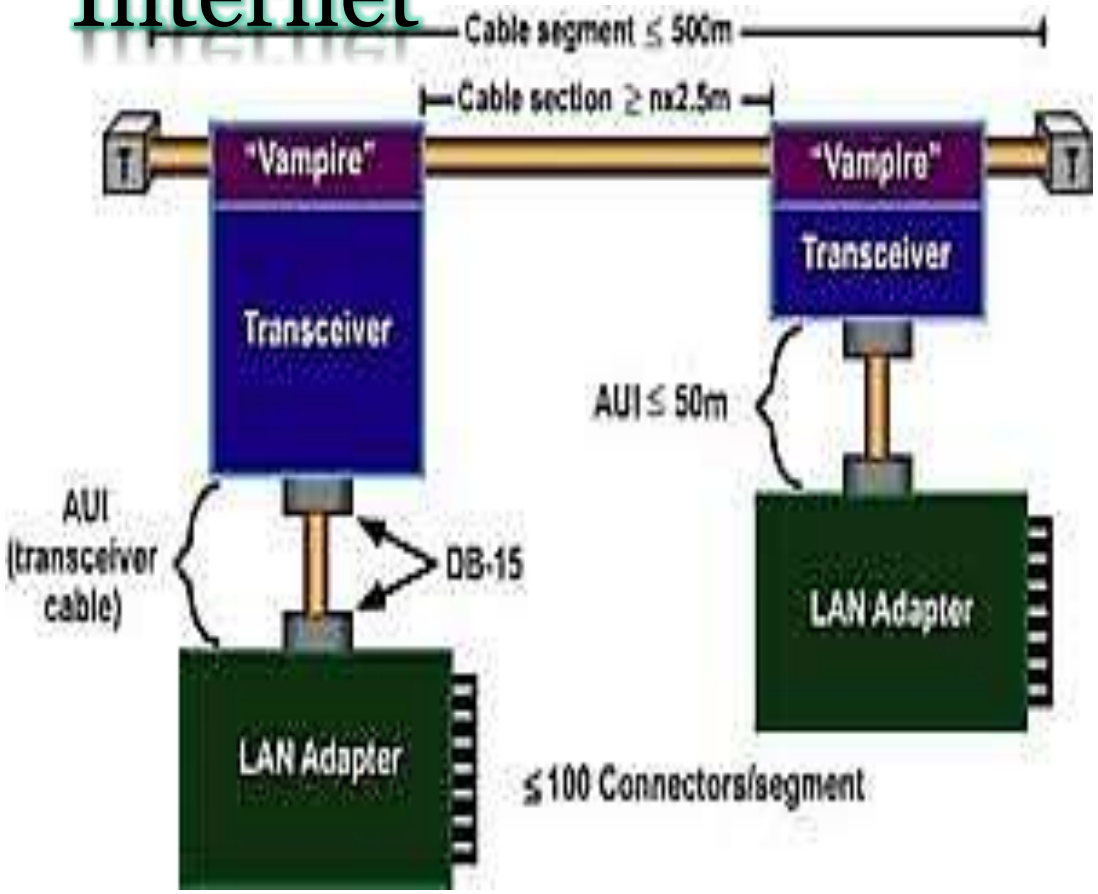
RELATIONSHIP BETWEEN SLOT TIME AND MAXIMUM NETWORK LENGTH:

$$\text{Max Length} = \frac{\text{Propagation speed} \times \text{slot time}}{2}$$

CATEGORIES OF STANDARD ETHERNET



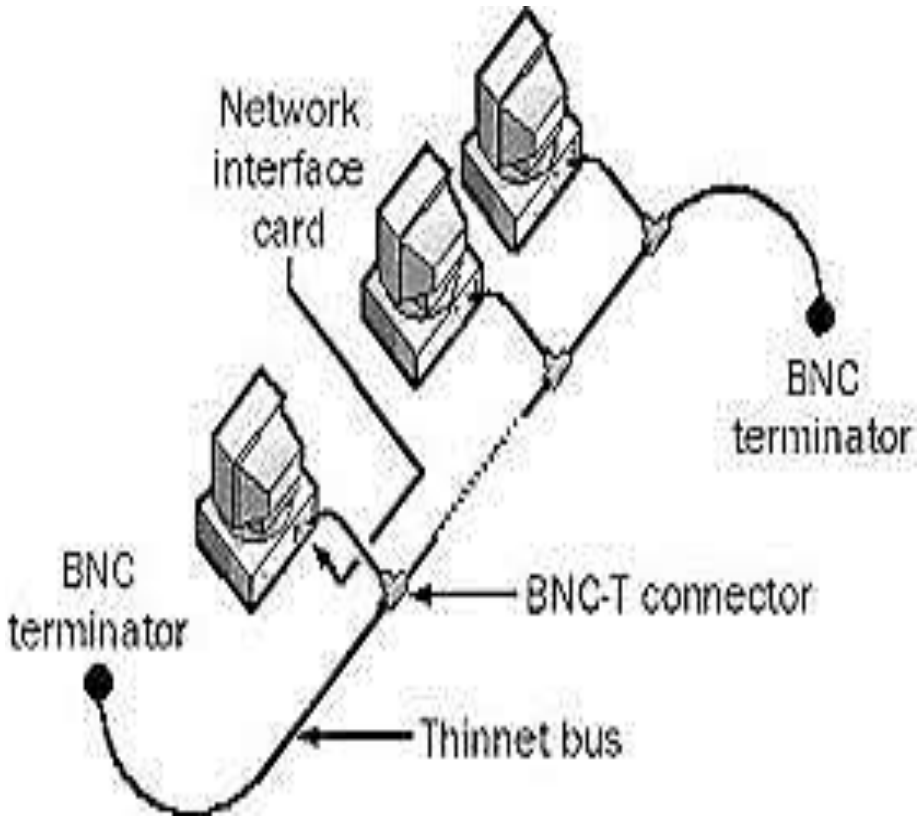
10Base5:Thick Internet



- The name *10BASE5* is derived from several characteristics of the physical medium. The *10* refers to its transmission speed of 10 Mbit/s. The *BASE* is short for baseband signaling as opposed to broadband, and the *5* stands for the maximum segment length of 500 meters (1,600 ft.).

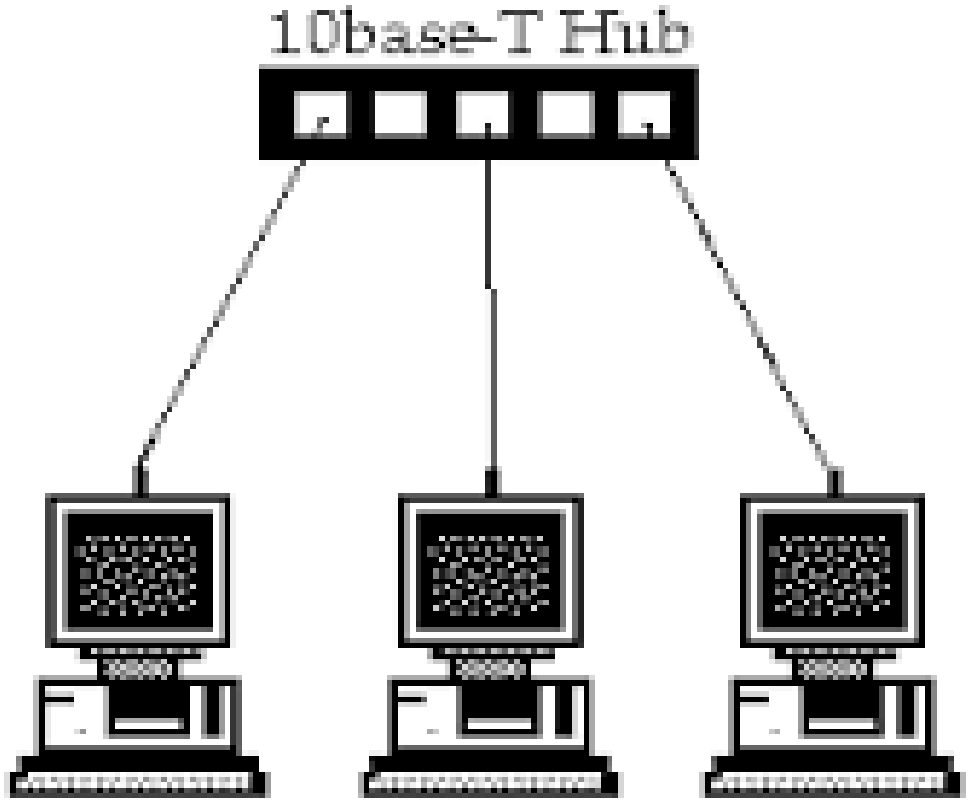
- It was the first Ethernet specification to use a bus topology with a external transceiver connected via a tap to a thick coaxial cable.

10base2:Thin Internet



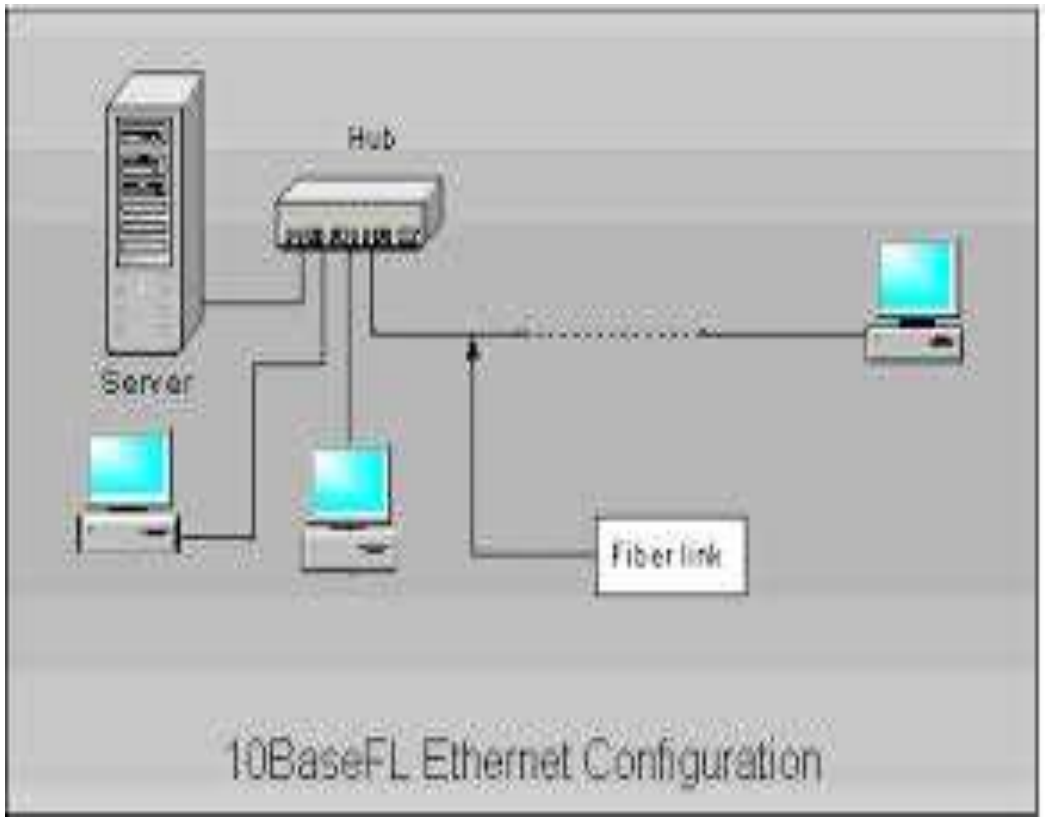
- The second implementation is called 10Base2,thin Ethernet , cheaper net .
- The cable is thinner and more flexible.
- The transceiver is a part of NIC , which is installed inside the station.
- The implementation is most cost effective than 10Base5as thin coaxial cable is less expensive than thick coaxial cable and the tee connection are much cheaper than taps.

10Base-T:Twister Pair Ethernet



- The third implementation is called 10Base-T or Twisted Pair Ethernet.
- It uses star topology and the station are connected via two pairs of twisted cable(one fro sending and one for receiving)between the station and the hub.
- The maximum length of the twisted cable here is defined as 100m,to minimize the effect of attenuation in the twisted cable.

10Base-F:Fiber Ethernet



- Although there are several types of optical fiber 10Mbps Ethernet , the most common is called 10Base-F.
- 10Base-F uses a star topology to connect stations to a hub.
- The stations are connected to a hub using two-optic cables.

FAST ETHERNET

It was designed to compete with LAN protocols such as FDDI or Fiber channel . IEEE created Fast Ethernet under the name 802.3u.Fast Ethernet is backward-compatible with standard Ethernet , but it can transmit data 10 times faster at rate of100Mbps.

GOALS OF FAST ETHERNET:

- Upgrade the data rate to 100Mbps.
- Make it compatible with standard Ethernet.
- Keep the same 48 bit-address.
- Keep the same frame format.
- Keep the same minimum and maximum frame lengths.

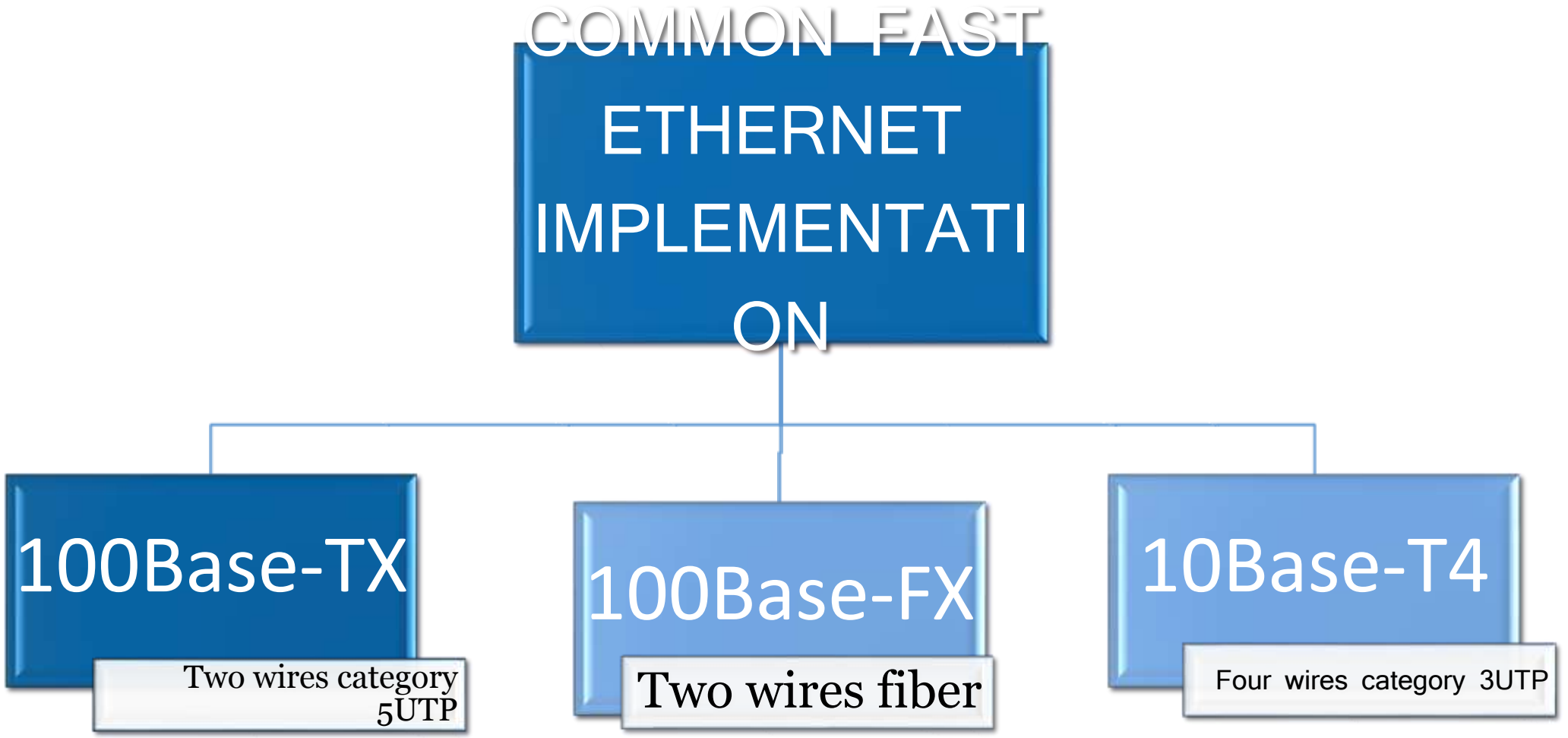
AUTONEGOTIATION :

It is a new feature is added to the Fast Ethernet . It allows a station or a hub a range of capabilities .

It was designed for the following purposes:

- To allow incompatible devices to connect to one another.
- To allow on devices to have multiple capabilities.
- To allow a station to check a hub's capabilities.

FAST ETHERNET IMPLEMENTATION

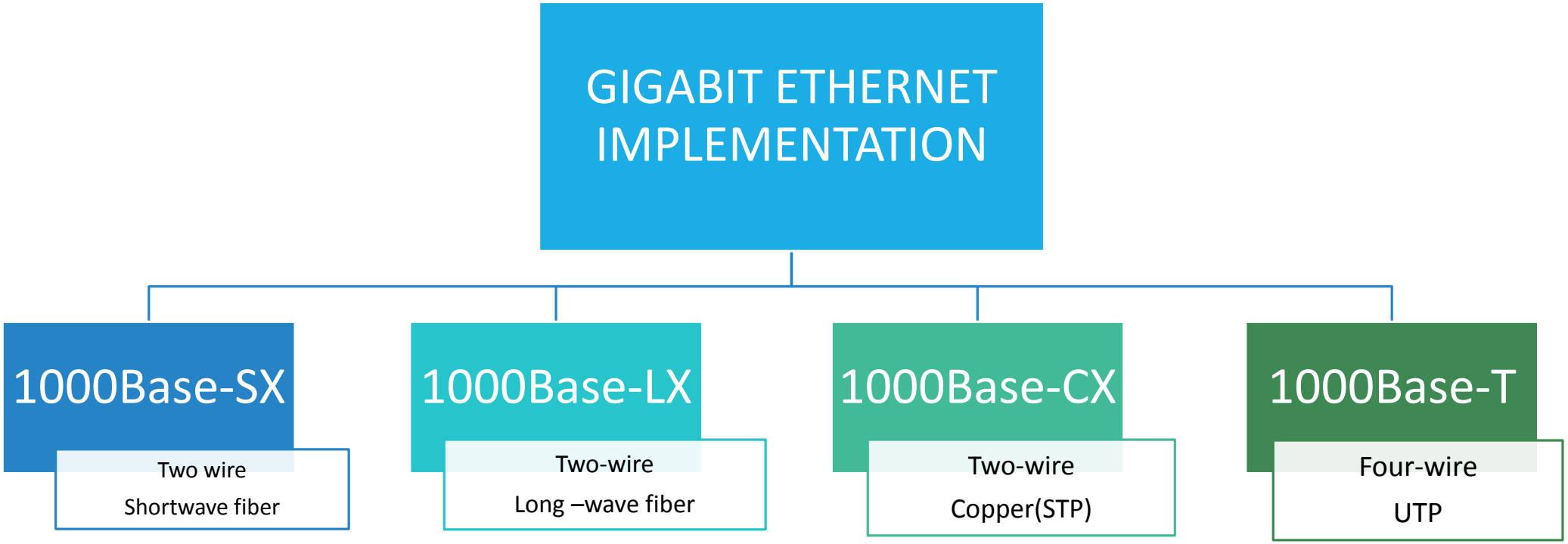


GIGABIT ETHERNET

- In computer networking, **Gigabit Ethernet** (**Gb E** or **1 GigE**) is a term describing various technologies for transmitting Ethernet frames at a rate of a gigabit per second (1,000,000,000 bits per second), as defined by the IEEE 802.3-2008 standard.
- . Fast Ethernet increased speed from 10 to 100 megabits per second (Mbit/s). Gigabit Ethernet was the next iteration, increasing the speed to 1000 Mbit/s. The initial standard for Gigabit Ethernet was produced by the IEEE in June 1998 as **IEEE 802.3z**, and required optical fiber. 802.3z is commonly referred to as 1000BASE-X, where -X refers to either -CX, -SX, -LX, or (non-standard) -ZX. For the history behind the "X" see Fast Ethernet.
- **IEEE 802.3ab**, ratified in 1999, defines Gigabit Ethernet transmission over unshielded twisted pair (UTP) category 5, 5e, or 6 cabling and became known as 1000BASE-T. With the ratification of 802.3ab, Gigabit Ethernet became a desktop technology as organizations could use their existing copper cabling infrastructure.
- **IEEE 802.3ah**, ratified in 2004 added two more gigabit fiber standards, 1000BASE-LX10 (which was already widely implemented as vendor specific extension) and 1000BASE-BX10. This was part of a larger group of protocols known as Ethernet in the First Mile.

GOALS OF GIGABIT ETHERNET

- Upgrade the data rate to 1Gbps.
- Make it compatible with standard or fast Ethernet.
- Use the same address ,frame format.
- Keep the same minimum and maximum frame length.
- To support auto negotiation as defined in Fast Ethernet.


GIGABIT ETHERNET IMPLEMENTATION
1000Base-SX
Two wire
Shortwave fiber
1000Base-LX
Two-wire
Long –wave fiber
1000Base-CX
Two-wire
Copper(STP)
1000Base-T
Four-wire
UTP

➢ 1000BASE-SX

1000BASE-SX is a fiber optic Gigabit Ethernet standard for operation over multi-mode fiber using a 770 to 860 nanometer, near infrared (NIR) light wavelength.

The standard specifies a distance capability between 220 meters (62.5/125 µm fiber with low modal bandwidth) and 550 meters (50/125 µm fiber with high modal bandwidth).

➢ 1000BASE-CX

1000BASE-CX is an initial standard for Gigabit Ethernet connections with maximum distances of 25 meters using balanced shielded twisted pair and either DE-9 or 8P8C connector (with a pinout different from 1000BASE-T). The short segment length is due to very high signal transmission rate.

➢ 1000BASE-T

1000BASE-T (also known as IEEE 802.3ab) is a standard for Gigabit Ethernet over copper wiring.

Each 1000BASE-T network segment can be a maximum length of 100 meters (330 feet), and must use Category 5 cable or better (including Cat 5e and Cat 6).

➢ 1000BASE-LX

1000BASE-LX is a fiber optic Gigabit Ethernet standard specified in IEEE 802.3 Clause 38 which uses a long wavelength laser (1,270–1,355 nm), and a maximum RMS spectral width of 4 nm.

1000BASE-LX is specified to work over a distance of up to 5 km over 10 μm single-mode fiber.

SUMMARY FOR GIGABIT ETHERNET IMPLEMENTATION

Name	Medium	Specified distance
1000BASE-CX	Shielded balanced copper cable	25 meters
1000BASE-KX	Copper backplane	1 meter
1000BASE-SX	Multi-mode fiber	220 to 550 meters dependent on fiber diameter and bandwidth
1000BASE-LX	Multi-mode fiber	550 meters
1000BASE-LX	Single-mode fiber	5 km
1000BASE-LX10	Single-mode fiber using 1,310 nm wavelength	10 km
1000BASE-EX	Single-mode fiber at 1,310 nm wavelength	~ 40 km
1000BASE-ZX	Single-mode fiber at 1,550 nm wavelength	~ 70 km
1000BASE-BX10	Single-mode fiber, over single-strand fiber: 1,490 nm downstream 1,310 nm upstream	10 km
1000BASE-T	Twisted-pair cabling (Cat-5, Cat-5e, Cat-6, Cat-7)	100 meters
1000BASE-TX	Twisted-pair cabling (Cat-6, Cat-7)	100 meters

IEEE STANDARDS:

In 1985,the computer society of the IEEE started a project called , **Project 802,**to set standards to enable intercommunication among equipment from a variety of manufactures . Project 802 does not seek to replace any part of the OSI or the Internet model . Instead , it is away of specifying functions of the physical layer and the data link layer of major LAN protocols.

The IEEE has subdivided the data link layer into two sublayers : **Logical link control**

(LLC)and **media access control(MAC).**IEEE has also created several physical layer standards for different LAN protocols.

Notable IEEE Standards formats

IEEE 802	LAN/MAN
IEEE 802.1	Standards for LAN/MAN bridging and management and remote media access control (MAC) bridging.
IEEE 802.2	Standards for Logical Link Control (LLC) standards for connectivity.
IEEE 802.3	Ethernet Standards for Carrier Sense Multiple Access with Collision Detection (CSMA/CD).
IEEE 802.4	Standards for token passing bus access.
IEEE 802.24	Standards for Logical Link Control (LLC) standards for connectivity.
IEEE 802.5	Standards for token ring access and for communications between LANs and MANs
IEEE 802.6	Standards for information exchange between systems.
IEEE 802.7	Standards for broadband LAN cabling.
IEEE 802.8	Fiber optic connection.

IEEE 802.9	**Standards for integrated services, like voice and data.**
IEEE 802.10	Standards for LAN/MAN security implementations.
IEEE 802.11	Wireless Networking – "WiFi".
IEEE 802.12	Standards for demand priority access method.
IEEE 802.14	Standards for cable television broadband communications.
IEEE 802.15.1	Bluetooth
IEEE 802.15.4	Wireless Sensor/Control Networks – "ZigBee"
IEEE 802.15.6	Wireless Body Area Network[3] (BAN) – (e.g. Bluetooth low energy)
IEEE 802.16	Wireless Networking – "WiMAX"

IEEE 802

- **IEEE 802** refers to a family of IEEE standards dealing with local area networks and metropolitan area networks. More specifically, the IEEE 802 standards are restricted to networks carrying variable-size packets. (By contrast, in cell relay networks data is transmitted in short, uniformly sized units called cells. Isochronous networks, where data is transmitted as a steady stream of octets, or groups of octets, at regular time intervals, are also out of the scope of this standard.)

- The services and protocols specified in IEEE 802 map to the lower two layers (Data Link and Physical) of the seven-layer OSI networking reference model. In fact, IEEE 802 splits the OSI Data Link Layer into two sub-layers named Logical Link Control (LLC) and Media Access Control (MAC), so that the layers can be listed like this:

- Data link layer
  - LLC Sublayer
  - MAC Sublayer
- Physical layer

Working groups:

Name	Description	Note
IEEE 802.1	Bridging (networking) and Network Management	
IEEE 802.2	LLC	inactive
IEEE 802.3	Ethernet	
IEEE 802.4	Token bus	disbanded
IEEE 802.5	Defines the MAC layer for a Token Ring	inactive
IEEE 802.6	MANs (DQDB)	disbanded
IEEE 802.7	Broadband LAN using Coaxial Cable	disbanded
IEEE 802.8	Fiber Optic TAG	disbanded
IEEE 802.9	Integrated Services LAN (ISLAN or isoEthernet)	disbanded
IEEE 802.10	Interoperable LAN Security	disbanded
IEEE 802.11	Wireless LAN (WLAN) & Mesh (Wi-Fi certification)	
IEEE 802.12	100BaseVG	disbanded
IEEE 802.13	Unused	Reserved for Fast Ethernet development
IEEE 802.14	Cable modems	disbanded

IEEE 802.15	Wireless PAN	
IEEE 802.15.1	Bluetooth certification	
IEEE 802.15.2	IEEE 802.15 and IEEE 802.11 coexistence	
IEEE 802.15.3	High-Rate wireless PAN (e.g., UWB, etc.)	
IEEE 802.15.4	Low-Rate wireless PAN (e.g., ZigBee, WirelessHART, MiWi, etc.)	
IEEE 802.15.5	Mesh networking for WPAN	
IEEE 802.15.6	Body area network	
IEEE 802.16	Broadband Wireless Access (WiMAX certification)	
IEEE 802.16.1	Local Multipoint Distribution Service	
IEEE 802.17	Resilient packet ring	
IEEE 802.18	Radio Regulatory TAG	
IEEE 802.19	Coexistence TAG	
IEEE 802.20	Mobile Broadband Wireless Access	
IEEE 802.21	Media Independent Handoff	
IEEE 802.22	Wireless Regional Area Network	
IEEE 802.23	Emergency Services Working Group	
IEEE 802.24	Smart Grid TAG	New (November, 2012)
IEEE 802.25	Omni-Range Area Network	Not yet ratified

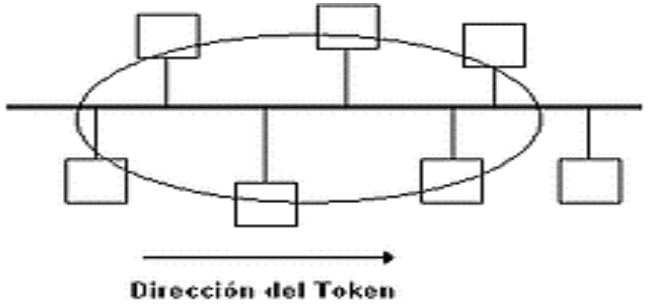
IEEE 802.3

- **IEEE 802.3** is a working group and a collection of IEEE standards produced by the working group defining the physical layer and data link layer's media access control (MAC) of wired Ethernet. This is generally a local area network technology with some wide area network applications.
- Physical connections are made between nodes and/or infrastructure devices (hubs, switches, routers) by various types of copper or fiber cable.
- 802.3 is a technology that supports the IEEE 802.1 network architecture.
- 802.3 also defines LAN access method using CSMA/CD.

COMMUNICATION STANDARDS

802.3-2012	**2012**	**A revision of base standard incorporating the 802.3at/av/az/ba/bc/bd/bf/bg amendments, a corrigenda and errata.**
802.3bj	June 2014	Define a 4-lane 100 Gbit/s backplane PHY for operation over links consistent with copper traces on “improved FR-4” (as defined by IEEE P802.3ap or better materials to be defined by the Task Force) with lengths up to at least 1m and a 4-lane 100 Gbit/s PHY for operation over links consistent with copper twinaxial cables with lengths up to at least 5m.
802.3bk	2013	This amendment to IEEE Std 802.3 defines the physical layer specifications and management parameters for EPON operation on point-to-multipoint passive optical networks supporting extended power budget classes of PX30, PX40, PRX40, and PR40 PMDs.
802.3bm	2015	100G/40G Ethernet for optical fiber
802.3bp	2014	1000BASE-T1 - Gigabit Ethernet over a single twisted pair, automotive & industrial environments
802.3bq	~Feb 2016	40GBASE-T for 4-pair balanced twisted-pair cabling with 2 connectors over 30 m distances
802.3bs	~ 2017	400 Gbit/s Ethernet over optical fiber using multiple 25G/50G lanes
802.3bt	~ 2017	Power over Ethernet enhancements up to 100W using all 4-pairs balanced twisted-pair cabling, lower standby power and specific enhancements to support Iot applications (e.g. Lighting, sensors, building automation).

Token bus network(802.4)



- **Token bus** is a network implementing the token ring protocol over a "virtual ring" on a coaxial cable.[A token is passed around the network nodes and only the node possessing the token may transmit. If a node doesn't have anything to send, the token is passed on to the next node on the virtual ring. Each node must know the address of its neighbor in the ring, so a special protocol is needed to notify the other nodes of connections to, and disconnections from, the ring.
- Token bus was standardized by IEEE standard 802.4. It is mainly used for industrial applications. The main difference is that the endpoints of the bus do not meet to form a physical ring.
- Due to difficulties handling device failures and adding new stations to a network, token bus gained a reputation for being unreliable and difficult to upgrade.
- In order to guarantee the packet delay and transmission in Token bus protocol, a modified Token bus was proposed in Manufacturing Automation Systems and flexible manufacturing system (FMS).
- A means for carrying Internet Protocol over token bus was developed.
- The IEEE 802.4 Working Group is disbanded and the standard has been withdrawn by the IEEE.

Token Ring/IEEE 802.5

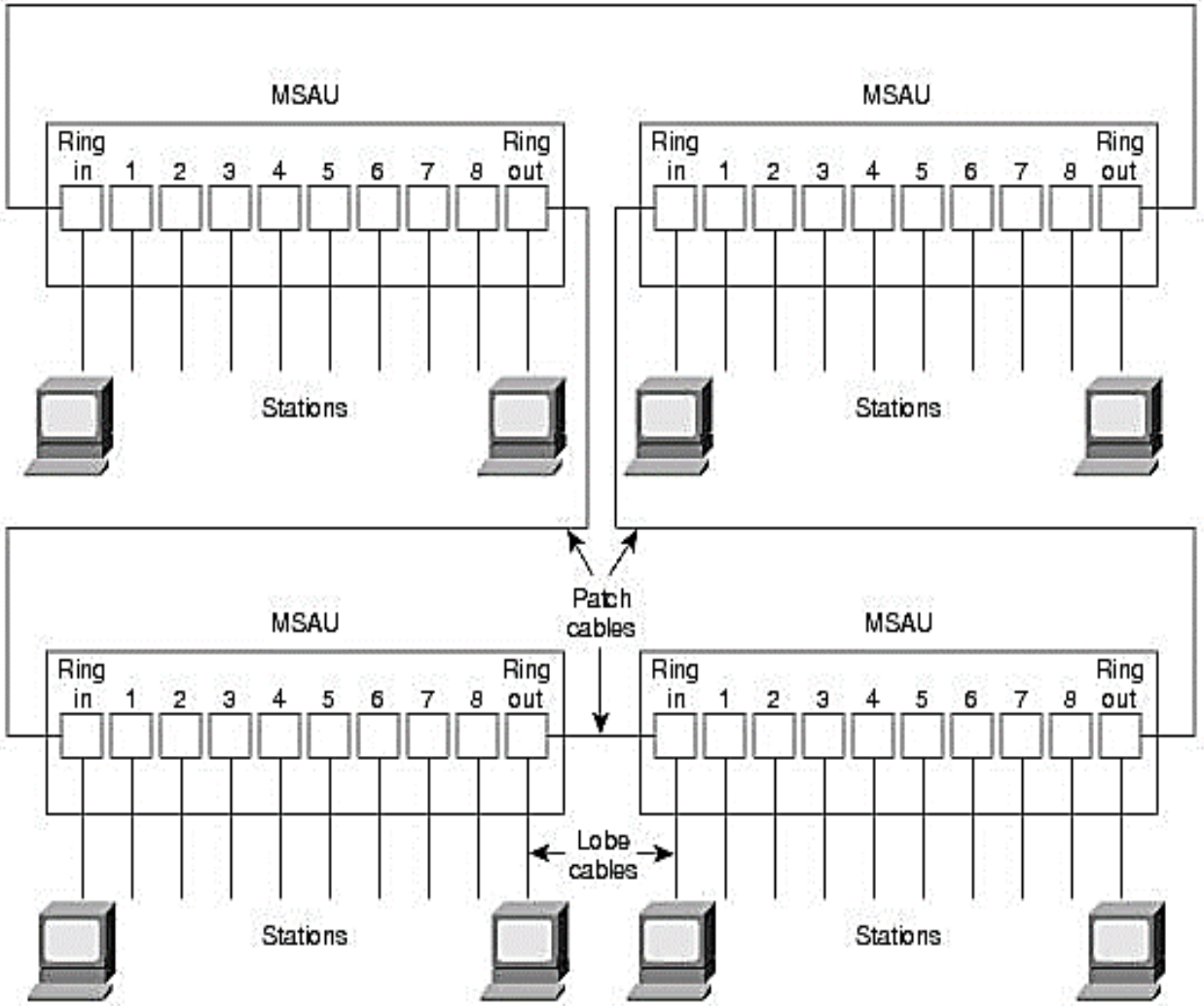
- The Token Ring network was originally developed by IBM in the 1970s. It is still in IBM's primary local-area network (LAN) technology. The related IEEE 802.5 specification is almost identical to and completely compatible with IBM's Token Ring network.

- Token Ring and IEEE 802.5 networks are basically compatible, although the specifications differ in minor ways. IBM's Token Ring network specifies a star, with all end stations attached to a device called a multi station access unit (MSAU). In contrast, IEEE 802.5 does not specify a topology, although virtually all IEEE 802.5 implementations are based on a star.

Physical Connections

IBM Token Ring network stations are directly connected to MSAUs, which can be wired together to form one large ring (see Figure: MSAUs Can Be Wired Together to Form One Large Ring in an IBM Token Ring Network).

Patch cables connect MSAUs to adjacent MSAUs, while lobe cables connect MSAUs to stations. MSAUs include bypass relays for removing stations from the ring.



Token Ring Operation

Token Ring and IEEE 802.5 are two principal examples of token-passing networks (FDDI is the other). Token-passing networks move a small frame, called a token, around the network. Possession of the token grants the right to transmit. If a node receiving the token has no information to send, it passes the token to the next end station. Each station can hold the token for a maximum period of time

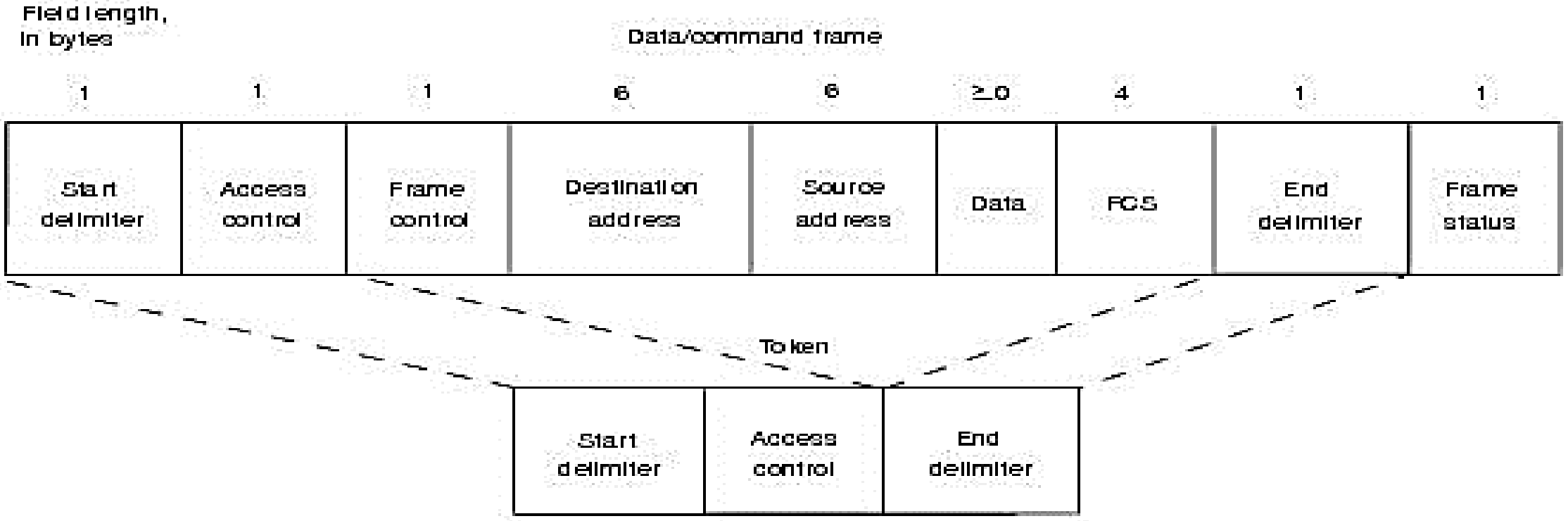
.

If a station possessing the token does have information to transmit, it seizes the token, alters 1 bit of the token (which turns the token into a start-of-frame sequence), appends the information that it wants to transmit, and sends this information to the next station on the ring.Therefore, collisions cannot occur in Token Ring networks. If early token release is supported, a new token can be released when frame transmission is complete.

Frame Format

Token Ring and IEEE 802.5 support two basic frame types: tokens and data/command frames.

Figure: IEEE 802.5 and Token Ring Specify Tokens and Data/Command Frames.



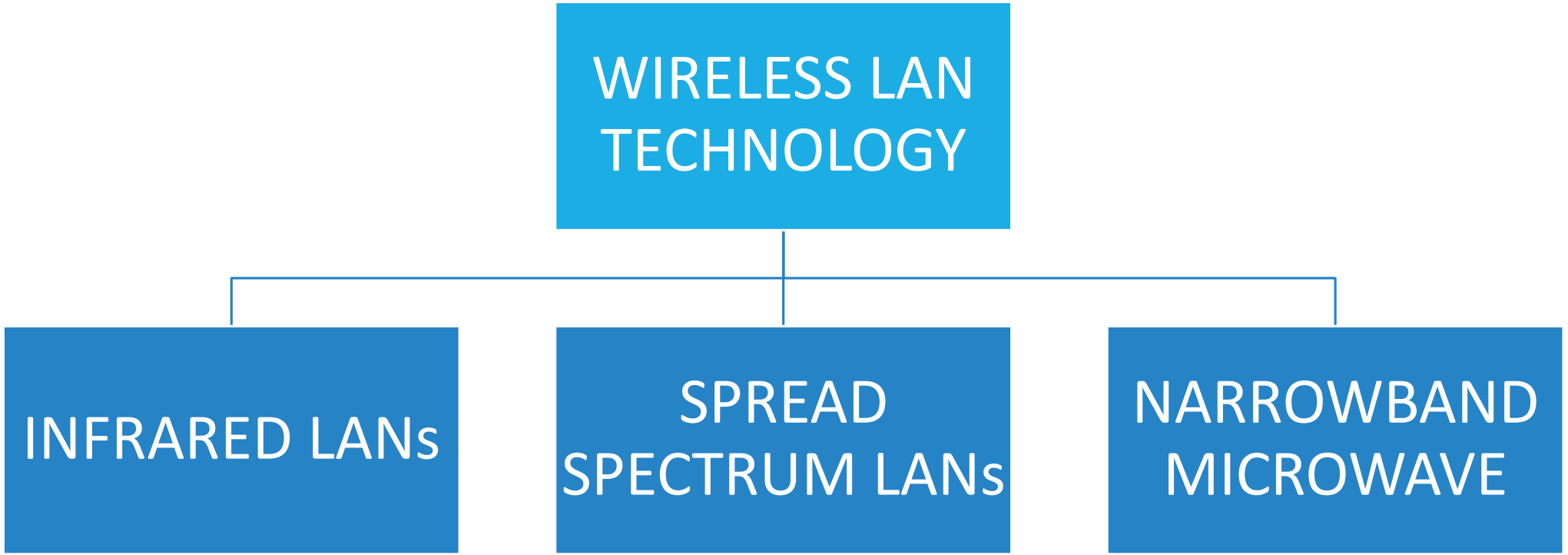
IEEE 802.6

- **IEEE 802.6** is a standard governed by the ANSI for Metropolitan Area Networks (MAN). It is an improvement of an older standard (also created by ANSI) which used the Fiber distributed data interface (FDDI) network structure. The FDDI-based standard failed due to its expensive implementation and lack of compatibility with current LAN standards.

- The IEEE 802.6 standard uses the Distributed Queue Dual Bus (DQDB) network form. This form supports 150 Mbit/s transfer rates. It consists of two unconnected unidirectional buses. DQDB is rated for a maximum of 160 km before significant signal degradation over fiber optic cable with an optical wavelength of 1310 nm.

- This standard has also failed, mostly for the same reasons that the FDDI standard failed. Most MANs now use Synchronous Optical Network (SONET) or Asynchronous Transfer Mode (ATM) network designs, with recent designs using native Ethernet or MPLS.

WIRELESS LAN TECHNOLOGY



IEEE 802.11:

In 1990,the IEEE 802 committee formed a new working group , IEEE 802.11 specifically devoted to wireless LANs , with a character to develop a MAC protocol and physical medium specification.

The demand of the for WANs , at different frequencies and data rates,has exploded.

Keeping pace with demand ,the IEEE802.11 working group has issued an ever-expanding list of standards.

Within the IEEE 802.11 Working Group , the following IEEE Standards Association Standard and Amendments exist:

- IEEE 802.11-1997: The WLAN standard was originally 1 Mbit/s and 2 Mbit/s, 2.4 GHz RF and infrared (IR) standard (1997), all the others listed below are Amendments to this standard, except for Recommended Practices 802.11F and 802.11T.
- IEEE 802.11a: 54 Mbit/s, 5 GHz standard (1999, shipping products in 2001)
- IEEE 802.11b: Enhancements to 802.11 to support 5.5 Mbit/s and 11 Mbit/s (1999)
- IEEE 802.11c: Bridge operation procedures; included in the IEEE 802.1D standard (2001)
- IEEE 802.11d: International (country-to-country) roaming extensions (2001)
- IEEE 802.11F: Inter-Access Point Protocol (2003) Withdrawn February 2006
- IEEE 802.11g: 54 Mbit/s, 2.4 GHz standard (backwards compatible with b) (2003)
- IEEE 802.11h: Spectrum Managed 802.11a (5 GHz) for European compatibility (2004)
- IEEE 802.11i: Enhanced security (2004)
- IEEE 802.11j: Extensions for Japan (2004)
- IEEE 802.11-2007: A new release of the standard that includes amendments a, b, d, e, g, h, i, and j. (July 2007)
- IEEE 802.11k: Radio resource measurement enhancements (2008)

BLUETOOTH

- BLUETOOTH is a wireless LAN designed to connect devices for different function such as telephones , computers(desktop and laptop),cameras ,printers , coffee makers and so on.

- It is an ad hoc network which means the network is formed spontaneously ; these devices find each other and make a network called a PICONET.

- Bluetooth technology is a implementation of a protocol defined by the IEEE 802.15 standard

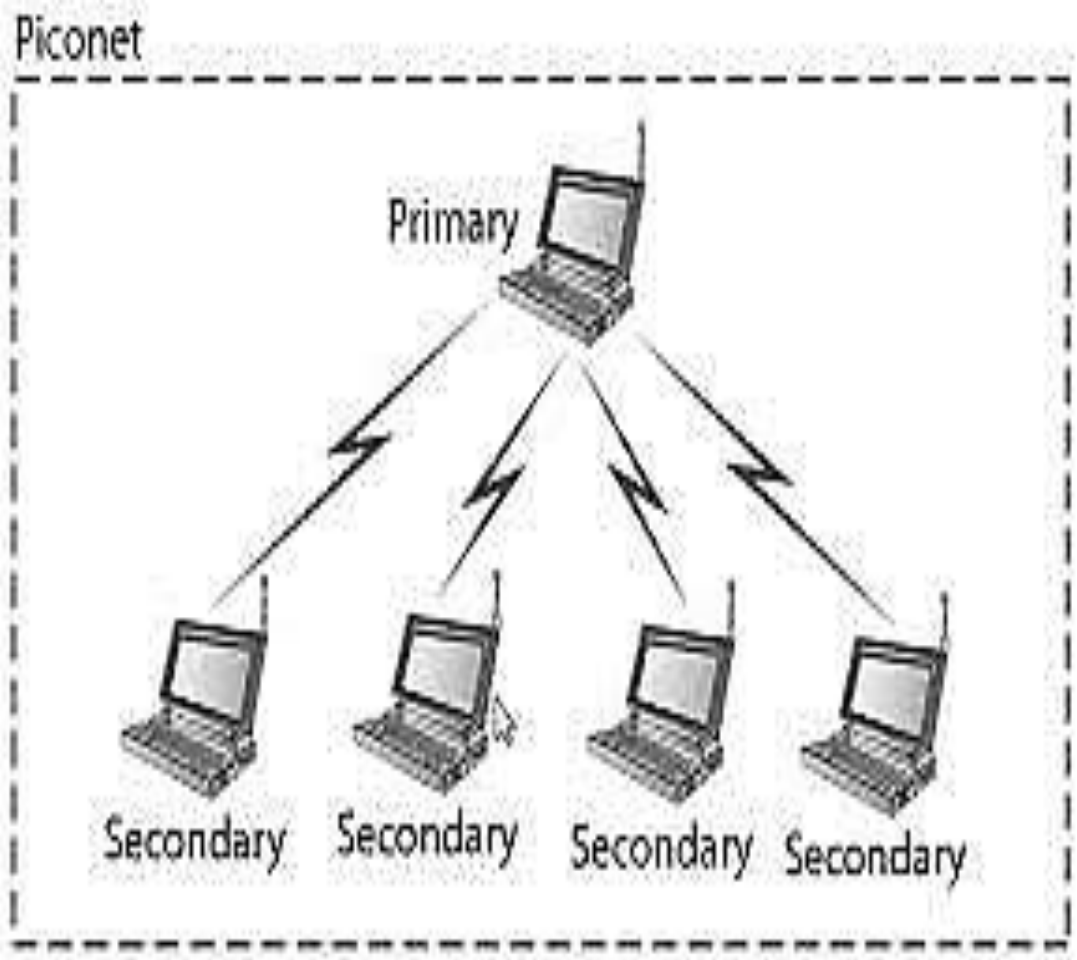
- Bluetooth was originally started as a project by the Ericson Company . It is named for HaraldBlaatand , the king of Denmark , later translates to Bluetooth in English.

ARCHITECTURE :

It defines two types of network

- Piconet
- Scatternet

PICONET



- A bluetooth network is called a piconet/small net.
- It can have up to eight stations , one of which is called the primary ; the rest are called secondaries.
- The communication between the primary and secondary can be one-to-one or one-to-many.

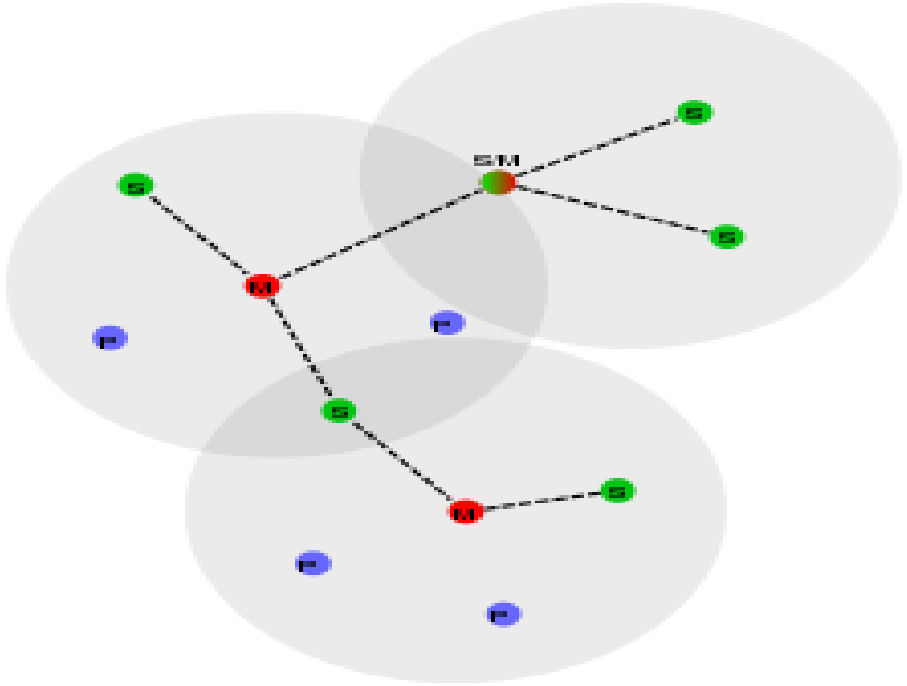
A **piconet** is a computer network which links a wireless user group of devices using Bluetooth technology protocols. A piconet consists of two or more devices occupying the same physical channel (synchronized to a common clock and hopping sequence).

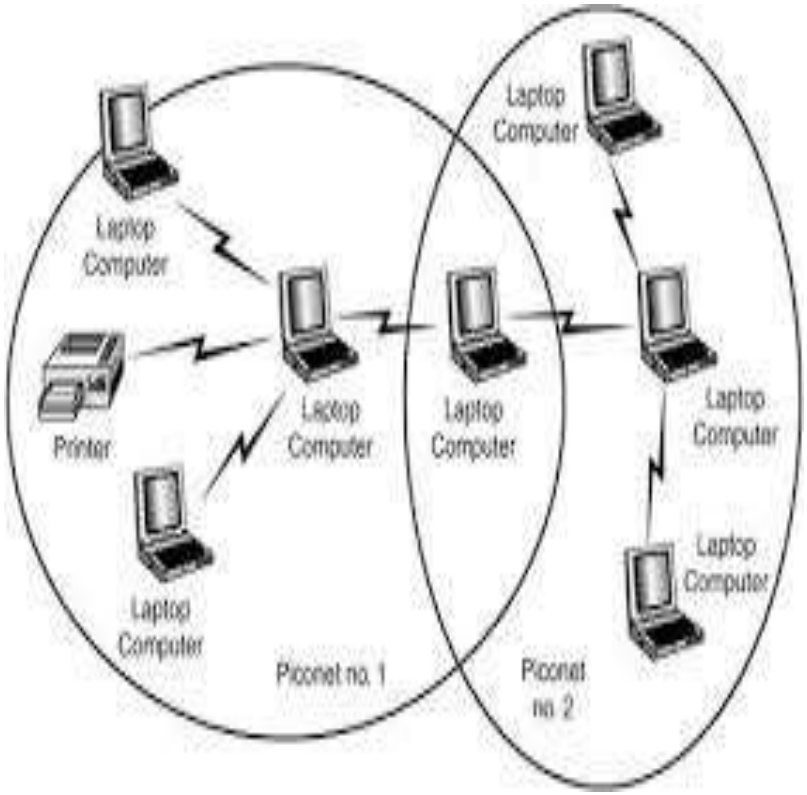
It allows one *master* device to interconnect with up to seven active *slave* devices. Up to 255 further slave devices can be inactive, or *parked*, which the master device can bring into active status at any time.

Some examples of piconets include a cell phone connected to a computer, a laptop and a Bluetooth-enabled digital camera, or several PDAs that are connected to each other

SCATTERNET

Scatternet (master=red, slave=green, parking=blue)
A **scatternet** is a type of ad hoc computer network consisting of two or more piconets. The terms 'scatternet' and 'piconet' are typically applied to Bluetooth wireless technology.





- A *scatternet* is a number of interconnected piconets that supports communication between more than 8 devices.
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- Scatternets can be formed when a member of one piconet (either the master or one of the slaves) elects to participate as a slave in a second, separate piconet. The device participating in both piconets can relay data between members of both ad hoc networks.

- Using this approach, it is possible to join together numerous piconets into a large scatternet, and to expand the physical size of the network beyond Bluetooth's limited range.
- Currently there are very few actual implementations of scatternets due to limitations of Bluetooth and the MAC address protocol.

Future applications

- Scatternets have the potential to bring the interconnectivity of the Internet to the physical world through wireless devices.

- A number of companies have attempted to launch social networking and dating services that leverage early scatternet implementations (see Blue dating).

- Scatternets can also be used to enable ad hoc communication and interaction between autonomous robots and other devices.