What is Gigabit Ethernet (GbE)?

- **Gigabit Ethernet (GbE), a transmission technology based on the Ethernet frame format and protocol used in local area networks (LANs), provides a data rate of 1 billion bits per second, or 1 gigabit (Gb).**

- **Gigabit Ethernet is defined in the Institute of Electrical and Electronics Engineers (IEEE) 802.3 standard and is currently being used as the backbone in many enterprise networks.**

- **Gigabit Ethernet connects computers and servers in local networks. Its improvements in data transfer speed and cabling have prompted many enterprises to replace Fast Ethernet with Gigabit Ethernet for wired local networks.**

- **Gigabit Ethernet is carried on optical fiber or copper wire. Existing Ethernet LANs with 10 megabits per second and 100 Mbps cards can feed into a Gigabit Ethernet backbone**.

Newer standards, such as 10 GbE, a networking standard that is 10 times faster than Gigabit Ethernet, are also emerging. Today, data centers and enterprises have a myriad of options of Gigabit Ethernet speeds, including 10 GbE, 20 GbE, 40 GbE and 100 GbE for core switching.

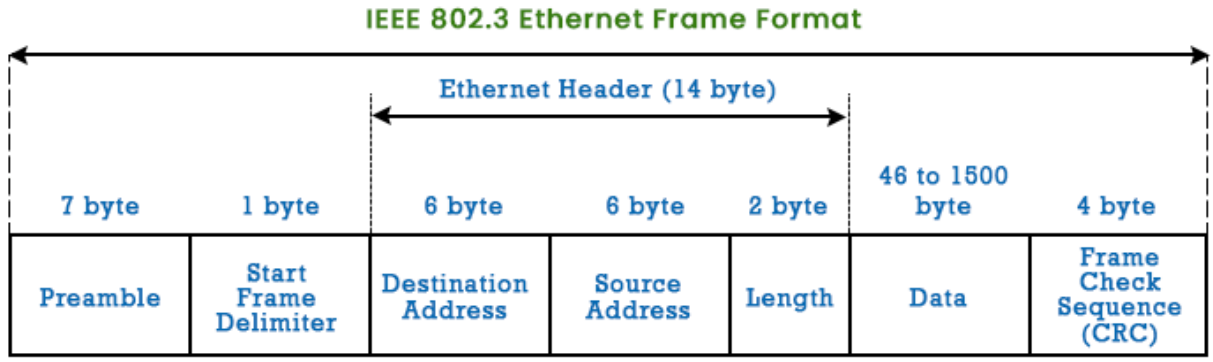
How Gigabit Ethernet works

Gigabit Ethernet networks can function as half-duplex networks for shared media or as Ethernet switches with a switched full-duplex network.

Gigabit Ethernet uses the same 802.3 framing structure as standard Ethernet. It supports 1 Gb per second (Gbps) speeds using Carrier Sense Multiple Access/Collision Detect (CSMA/CD). CSMA/CD handles transmissions after a collision has occurred.

Complete illustration of Extended Ethernet Frame (Ethernet II frame):

Below, a thorough explanation of the IEEE 802.3 basic frame format is provided. Let's look at the expanded Ethernet frame header, which allows for a payload of even more than 1500 bytes.



DA [Destination MAC Address]: ***6 bytes***

SA [Source MAC Address]: ***6 bytes***

Type [0x8870 (Ethertype)]: ***2 bytes***

DSAP [802.2 Destination Service Access Point]: ***1 byte***

SSAP [802.2 Source Service Access Point]: ***1 byte***

Ctrl [802.2 Control Field]: ***1 byte***

Data [Protocol Data]: ***> 46 bytes***

FCS [Frame Checksum]: ***4 bytes***

Although the Ethernet II frame lacks a length field, the network interface knows the frame length because it accepts the frame.

The transmission rate may cause data packets to intersect when two devices on the same Ethernet network atempt to transmit data at the same time. CSMA/CD detects and discards collided data packets.

Gigabit Ethernet speeds are delivered by either copper or fiber optic cables. Fiber optic cables are needed for long-range transmissions of more than 300 meters (m).

However, traditional Ethernet cables can transmit data at gigabit speeds over shorter distances -- in particular, Cat5e cables or above or the 1000Base-T cabling standard and above. Cat5e cable, for example, consists of four pairs of eight twisted wires in one cable.

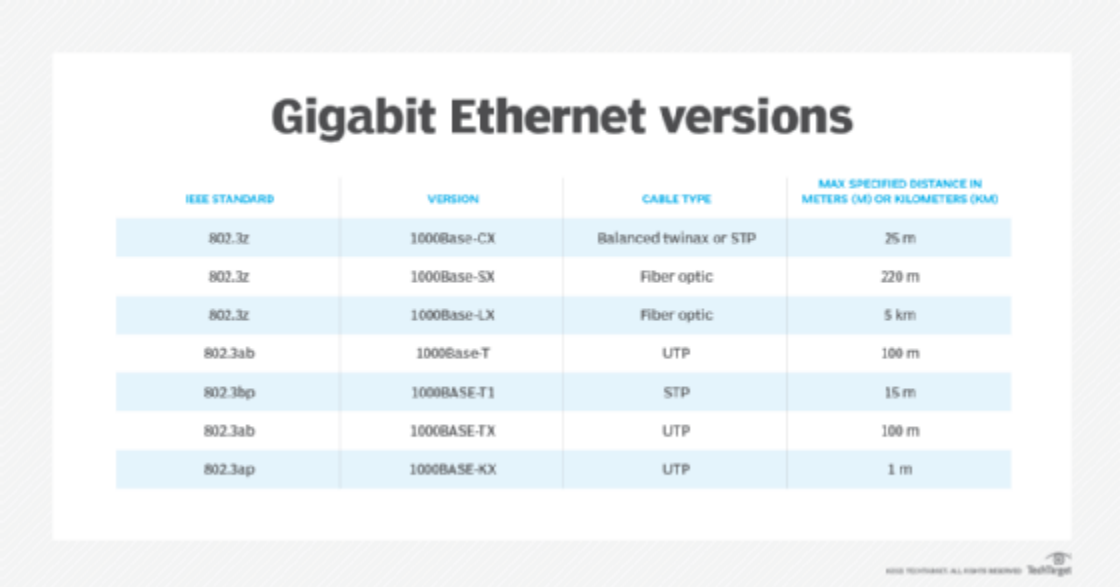
Features of Gigabit Ethernet :

- It supports two different modes i.e. full-duplex mode and half-duplex mode.
- In this mode, contention is not possible. With a network, a contention is when two or more computers try to access the same file at the same time.
- A half-duplex mode is used when computers are connected to a hub rather than a switch. A hub does not buffer incoming frames.
- All the lines are electrically connected internally, simulating the multi-drop cable used in classic Ethernet. Standard CSMA/CD protocol is required in this mode because collisions are possible. Because a 64-byte frame can now be transmitted 100 times faster than in classic Ethernet, the maximum cable length must be 100 times less or 25 meters.
  A collision in a computer network occurs when two or more data packets attempt to use the same network channel at the same time, causing them to interfere with each other.

Types of Gigabit Ethernet

Gigabit Ethernet is implemented in different cabling physical layer standards, including the following:

- **1000Base-CX.** This standard, which is used for connections up to 25 m, uses either balanced twinaxial cabling or shielded twisted pair (STP) cabling.
- **1000Base-SX.** This standard, which is used for connections up to 220 m, uses fiber optic cables for short-wavelength transmissions.
- **1000Base-LX.** This standard, which is used for connections up to a maximum distance of 5 kilometers (km), uses fiber optic cables.
- **1000Base-T.** This standard, which is used for connections up to 100 m, uses unshielded twisted pair (UTP) copper cables with Cat5, Cat5e, Cat6 and Cat7.
- **1000BASE-T1.** This standard, which is used for connections up to 15 m, uses STP copper cables.
- **1000BASE-TX.** This standard, which is similar to 1000Base-T, is used for connections up to 100 m. It uses UTP copper cables. But this standard does not receive much recognition due to its cost and Cat6 and Cat7 cable requirements.
- **1000BASE-KX.** This standard, which is used for connections up to 1 m, uses UTP-type cables.



Gigabit Ethernet versions

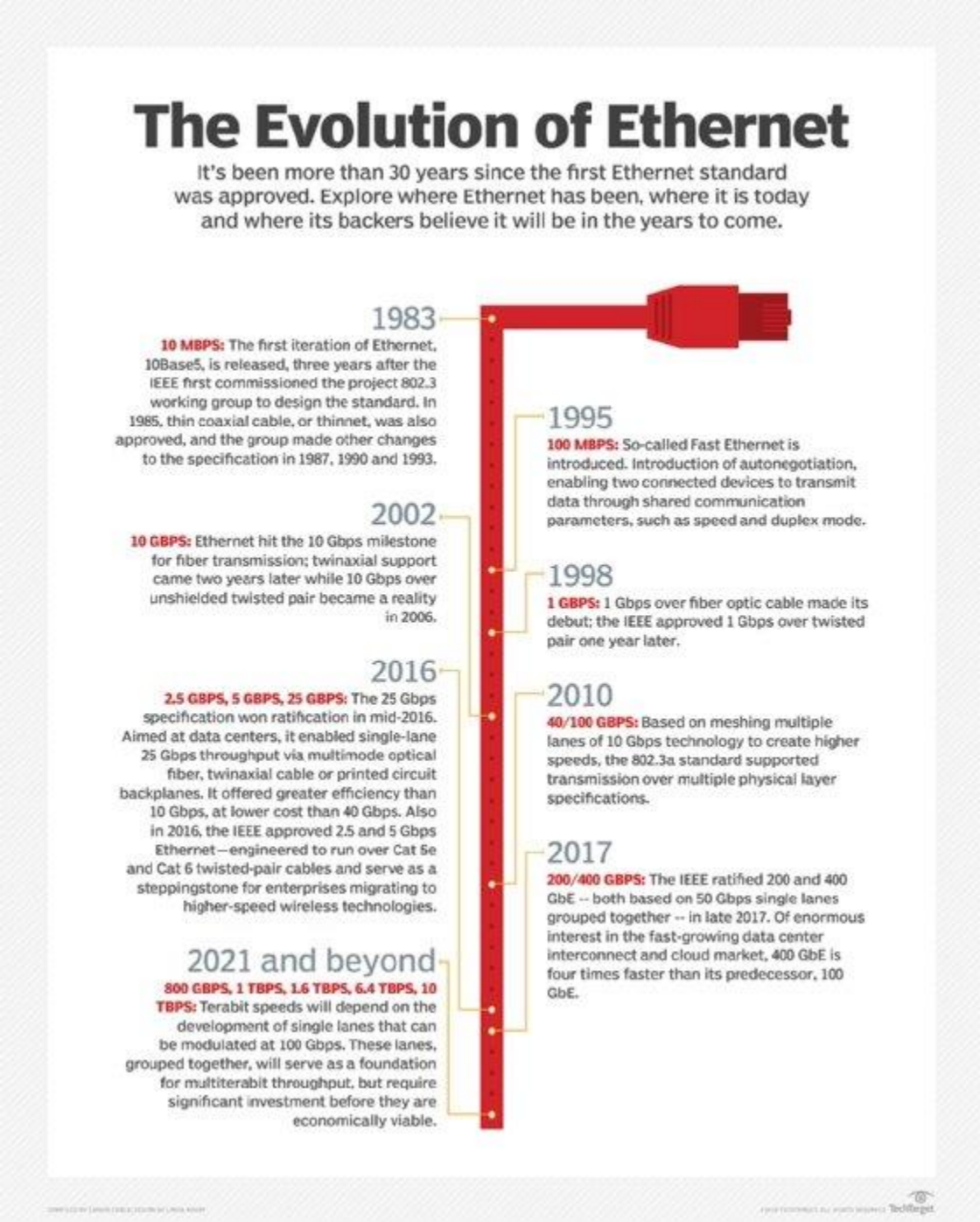
IEEE STANDARD	VERSION	CABLE TYPE	MAX SPECIFIED DISTANCE IN METERS (M) OR KILOMETERS (KM)
802.3z	1000Base-CX	Balanced twinax or STP	25 m
802.3z	1000Base-SX	Fiber optic	220 m
802.3z	1000Base-LX	Fiber optic	5 km
802.3ab	1000Base-T	UTP	100 m
802.3bp	1000BASE-T1	STP	15 m
802.3ab	1000BASE-TX	UTP	100 m
802.3ap	1000BASE-KX	UTP	1 m

This image shows several Gigabit Ethernet versions and specifications.

Benefits of Gigabit Ethernet

Gigabit Ethernet provides the following benefits:

- **Reliability.** Fiber optic cables used in some gigabit internet offerings are more durable and reliable than traditional copper wiring.
- **Speed.** A transmission speed of 1 Gbps should be more than enough for most online applications today.
- **Less latency.** Reduced latency rates range from 5 milliseconds to 20 ms.
- **Transferring or streaming video data.** Gigabit Ethernet can smoothly stream 4K content at a high frame rate.
- **Multiuser support.** High-speed internet can be split into multiple tasks to support multiple devices.



This timeline shows the evolution of Ethernet over the past 30 years.

History

As one of the most widely used LAN technologies, Ethernet was introduced in 1973 and has evolved over the years:

- In 1995, Fast Ethernet was introduced and, as a standard, remained the fastest version of Ethernet for three years. Fast Ethernet was designed to carry traffic at a rate of 100 Mbps.

- In 1998, three years after the introduction of Fast Ethernet, Gigabit Ethernet was introduced by IEEE to replace Fast Ethernet. It provided a data rate of 1 Gb and initially required the use of fiber optic cables.
- In 1999, a new standard was passed that enabled UTP Cat5, Cat5e or Cat6 cabling to be used. This was called 1000Base-T.
- In 2002, 10 GbE was introduced.
- In 2004, the 1000BASE-LX10 and 1000BASE-BX10 standards were added.
- In 2010, a standard for 40 GbE and 100 GbE was introduced to support endpoint and link aggregation.
- In 2013, IEEE published results from an Ethernet Study Group for a 400 GbE standard.
- In 2017, IEEE ratified 200 GbE and 400 GbE, which are two times and four times faster, respectively, than 100 GbE.
- The Ethernet Alliance's technology roadmap expects Ethernet speeds of 800 Gbps to 1.6 terabits per second to become an IEEE standard between 2023 and 2025.

Tables for different Ethernet :

- Gigabit Ethernet supports both copper and fiber cabling as shown in table 1. When sending signals at the speed of 1 Gbps then it requires encoding and at every nanosecond, a bit must be sent.
- This trick was initially accomplished with short, shielded copper cables and optical fibers. For the optical fibers, two wavelengths are permitted and result in two different versions: 0.85 microns and 1.3 microns.

Table-1: Gigabit Ethernet Cabling

Name	Cable	Max. Segment	Advantages
1000Base-SX	Fiber optics	550m	Multimode fiber (50, 62.5 microns)
1000Base-LX	Fiber optics	5000m	Single(10 µ) or multimode(50, 62.5 µ)

Name	Cable	Max. Segment	Advantages
1000Base-CX	2 pairs of STP	25m	Shielded twisted pair
1000Base-T	4 pairs of UTP	100m	Standard category 5 UTP

Overview

IEEE stands for Institute of Electrical and Electronics Engineers. The main AIM of IEEE is to foster technological innovation and excellence for the benefit of humanity.

The IEEE standards in computer networks ensure communication between various devices; it also helps to make sure that the network service, i.e., the Internet and its related technologies, must follow a set of guidelines and practices so that all the networking devices can communicate and work smoothly.

Since there are various types of computer system manufacturers, the IEEE's Computer Society started a project in 1985 called project 802 to enable standard communication between various devices. The standards that deal with computer networking are called the IEEE 802 wireless standards.

What are IEEE Standards in Computer Networks?

Before learning about the IEEE standards in computer networks, let us get a brief introduction to IEEE. IEEE, or **Institute of Electrical and Electronics Engineers, is an organization that develops standards for the electronics industry and computers. IEEE is composed of numerous scientists, engineers, and students from all over the globe. The main AIM of IEEE is to ensure foster technological innovation and excellence for the benefit of humanity.**

The IEEE standards in computer networks ensure communication between various devices; it also helps to make sure that the network service, i.e., the Internet and its related technologies, must follow a set of guidelines and practices so that all the networking devices can communicate and work smoothly.

There are various IEEE standards in computer networks:

1. **IEEE 802**: The IEEE 802 deals with the standards of LAN and MAN, i.e., Local Area Network and Metropolitan Area Network.
2. **IEEE 802.1**: The IEEE 802.1 deals with the standards of LAN and MAN. Along with that, it also deals with the MAC (Media Access Control) bridging.
3. **IEEE 802.2**: The IEEE 802.2 deals with the LLC (Logical Link Control).

Let us take an example of IEEE standards in computer networks. The IEEE 802.11 standard in computer networks is used in various homely devices like laptops, printers, smartphones, and various other devices that allow them to communicate with each other using the Internet. Hence, the IEEE 802.11 standard in computer networks is useful for devices that use wireless communication, i.e., WiFi bands.

Note: The IEEE 802.11 is a part of the IEEE 802 set of LAN technical standards.

List of IEEE Standards in Computer Networks

Let us look at the various IEEE standards in computer networks and their usage (or function):

IEEE standards in computer networks	Description
IEEE 802	It is used for the overview and architecture of LAN/MAN.
IEEE 802.1	It is used for bridging and management of LAN/MAN.
IEEE 802.1s	It is used in multiple spanning trees.
IEEE 802.1 w	It is used for rapid reconfiguration of spanning trees.
IEEE 802.1x	It is used for network access control of ports.
IEEE 802.2	It is used in Logical Link Control (LLC).
IEEE 802.3	It is used in Ethernet (CSMA/CD access method).
IEEE 802.3ae	It is used for 10 Gigabit Ethernet.
IEEE 802.4	It is used for token passing bus access methods and the physical layer specifications.
IEEE 802.5	It is used for token ring access methods and the physical layer specifications.
IEEE 802.6	It is used in distributed Queue Dual Bus (DQDB) access method and for the physical layer specifications (MAN).

IEEE standards in computer networks	Description
IEEE 802.7	It is used in broadband LAN.
IEEE 802.8	It is used in fiber optics.
IEEE 802.9	It is used in isochronous LANs.
IEEE 802.10	It is used in interoperable LAN/MAN security.
IEEE 802.11	It is used in wireless LAN, MAC, and Physical layer specifications.
IEEE 802.12	It is used in the demand-priority access method, in the physical layer, and in repeater specifications.
IEEE 802.13	It is not used.
IEEE 802.14	It is used in cable modems (not used now).
IEEE 802.15	It is used in WPAN (Wireless Personal Area Network).
IEEE 802.16	It is used in Wireless MAN (Wireless Metropolitan Area Network).
IEEE 802.17	It is used in RPR access (Resilient Packet Ring).

What is Fast Ethernet?

Fast Ethernet has transformed the landscape of communication enabling unparalleled speeds and unleashing a new era of connectivity through speed.

Primary Terminologies Related to Fast Ethernet

- **Ethernet:** Ethernet is a family of wired computers and It is a widely used networking technology that mainly defines the path of the data transmission over a wired connection. It works on the principle of packet switching and uses the ethernet protocol. Ethernet technology allows network-connected devices to communicate without packet collisions. In an Ethernet network, data is broken into packets.
- **Data Transfer Rate (DTR):** Data Transfer rate also known as Data Throughput. It is the speed at which the data is transmitted from one device to another within the connected network. DTR is mainly measured in bits per second(bps) or in major kilobits per second(Kbps).
- **Band Width:** It mainly refers to the maximum rate of data transfer across a connected network medium. These represent the capacity of the medium which can carry data up to what extent. Bandwidth is actually the volume of information that can be sent over a connection in a measured amount of time – calculated in megabits per second (Mbps).

Understanding Fast Ethernet

Fast Ethernet is a networking technology which is enhancement of traditional ethernet by increasing the data transfer rates.

Fast Ethernet represents a huge development over traditional Ethernet, addressing the growing demand for better data transfer rates in networking environments.

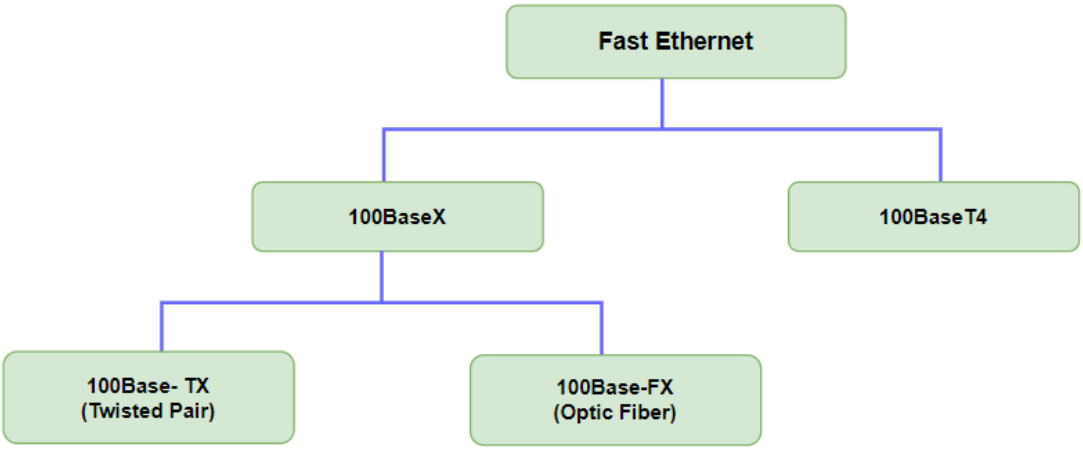
The original Ethernet standard, defined by means of the Institute of Electrical and Electronics Engineers (IEEE) 802.3 specification, operated at a speed of 10 Mbps. However, because the call for faster network speeds grew, the need for an advanced Ethernet standards became apparent.

Fast Ethernet, standardized below the IEEE 802.3u specification, brought several enhancements to get its higher data transfer rates. One of the key improvements changed into the use of different signaling methods and media types compared to traditional Ethernet. Fast Ethernet helps both twisted pair and fiber optic cabling.

Types of Fast Ethernet

Fast Ethernet is mainly of several types or standards, each having their own specifications, implementations and characteristics. The two most common types of Fast Ethernet are:

- 100Base-TX
- 100Base-FX



1. 100Base-TX

- 100Base-TX utilizes twisted pair copper cabling specified as Cat5e cables for the ease of data transmission.
- It is mainly used in Local Area Networks(LANs)
- It works on both Full duplex and Half Duplex Modes and it supports data transfer rates up to 100 Mbps.
- This is used in the connecting devices like computers. printers and LAN environment.

2. 100Base-FX

- 100Base-FX is another type of Fast Ethernet that is in different cabling which is fiber optic cabling for Data transmission
- It is mainly used in long run cables of range 120 Kms and it requires electro magnetic interference.
- It supports up to 100 Mbps of DTR and it also offers the higher bandwidth.
- This is used commonly in connecting devices across different buildings or in the environment where copper cabling is out of reach.

Significance of Fast Ethernet

The Significance of Fast Ethernet lies in the impact on networking capabilities, performance and Efficiency. Some Key points mentioned are the significance of Fast Ethernet below:

- Increased Data Transfer Rates
- Enhanced Network Performance
- Cost Effectiveness
- Scalability
- Flexibility
- Support for Bandwidth intensive applications (Video Conferencing, Multimedia streaming, Large File Transfers).

Applications of Fast Ethernet

The applications of Fast Ethernet are diverse in various industries and scenarios. The following are some of the applications for Fast Ethernet:

- **Data Centers:** Fast Ethernet is commonly deployed in data center environments to connect servers, storage devices, and networking equipment. It facilitates rapid data transfer between servers and storage arrays, supporting mission-critical applications and services hosted in the data center.
- **Surveillance Systems:** Fast Ethernet is utilized in surveillance systems for transmitting high-definition video feeds from IP cameras to monitoring stations or recording devices. It ensures real-time monitoring and recording of surveillance footage, enhancing security and surveillance capabilities.
- **Educational Institutions:** Fast Ethernet is employed in educational institutions, such as schools and universities, to support networked learning environments. It enables access to online educational resources, collaborative tools, and e-learning platforms, enriching the educational experience for students and educators.
- **Telecommunications:** Fast Ethernet is used in telecommunications networks for backhaul connections between central offices, cell towers, and network aggregation points. It enables the efficient transfer of voice, data, and video traffic over large-scale telecommunications networks.