Ethernet at the Physical Layer

by Sophia

WHAT'S COVERED

In this lesson, you will examine Ethernet at the Physical Layer.

Specifically, this lesson will cover the following:

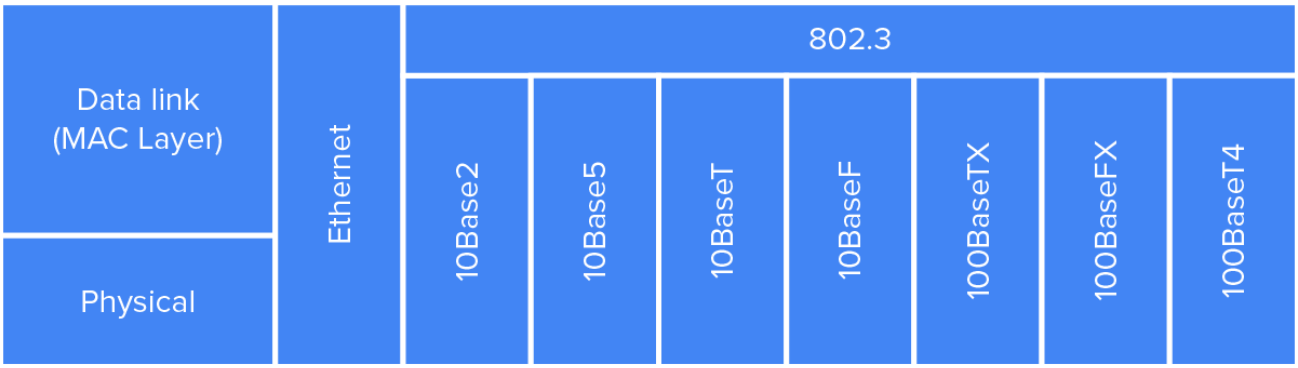
1. Ethernet at the Physical Layer
2. IEEE 802.3 Standards
    - 2a. 10Base2
    - 2b. 10Base5
    - 2c. 10BaseT
    - 2d. 802.3u
3. Expanded IEEE Ethernet 802.3 Standards
    - 3a. 100BaseTX (IEEE 802.3u)
    - 3b. 100BaseFX (IEEE 802.3u)
    - 3c. 1000BaseCX (IEEE 802.3z)
    - 3d. 1000BaseT (IEEE 802.3ab)
    - 3e. 1000BaseTX
    - 3f. 1000BaseSX (IEEE 802.3z)
    - 3g. 1000BaseLX (IEEE 802.3z)
    - 3h. 10GBaseT
    - 3i. 10GBaseSR
    - 3j. 10GBaseLR
    - 3k. 10GBaseER
    - 3l. 10GBaseSW
    - 3m. 10GBaseLW
    - 3n. 10GBaseEW

1. Ethernet at the Physical Layer

THINK ABOUT IT

Ethernet was first implemented by a group called DIX (Digital, Intel, and Xerox). They created and implemented the first Ethernet LAN specification, which the IEEE used to create the IEEE 802.3 Committee. This was a 10 Mbps network that ran on coax, then on twisted-pair, and finally on fiber physical media. The IEEE extended the 802.3 Committee to two new committees known as 802.3u (Fast Ethernet), 802.3ab (Gigabit Ethernet on Category 5+), and then finally to 802.3ae (10 Gbps over fiber and coax).

The diagram below shows the IEEE 802.3 and original Ethernet Physical layer specifications.



When designing your LAN, it is really important to understand the different types of Ethernet media available to you. Sure, it would be great to run Gigabit Ethernet to each desktop and 10 Gbps between switches, as well as to servers. Although this is just starting to happen, justifying the cost of that network today would be challenging for most companies. Instead, if you mix and match the different types of Ethernet media methods currently available, you can come up with a cost-effective network solution that works reliably.

Recall from a previous lesson that the Electronic Industries Association and the newer Telecommunications Industry Alliance (EIA/TIA) together form the standards body that creates the Physical Layer specifications for Ethernet. The EIA/TIA specifies that Ethernet uses a registered jack (RJ) connector on unshielded twisted-pair (UTP) cabling (RJ-45). However, the industry is calling this just an 8-pin modular connector.

Each Ethernet cable type that is specified by the EIA/TIA has something known as inherent **attenuation**, which is defined as the loss of signal strength as it travels the length of a cable and is measured in decibels (dB). The cabling used in corporate and home markets is measured in categories. A higher-quality cable will have a higher-rated category and lower attenuation. For example, Category 5 is better than Category 3 because Category 5 cables have more wire twists per foot and therefore less crosstalk. As discussed in a previous tutorial, crosstalk is the unwanted signal interference from adjacent pairs in the cable.

TERM TO KNOW

Attenuation

Signal loss over distance.

2. IEEE 802.3 Standards

2a. 10Base2

This is also known as Thinnet and can support up to 30 workstations on a single segment. It uses 10 Mbps of baseband technology, coaxes up to 185 meters in length, and a physical and logical bus with **Attachment Unit Interface (AUI)** connectors. The 10 means 10 Mbps, Base means baseband technology, which supports only one channel on the medium, and the 2 means almost 200 meters. 10Base2 Ethernet cards use BNC T-connectors to connect to a network. 10Base2 is a **legacy** network technology, which is an old system that may continue to be used because the owner does not want to replace or redesign it.

TERMS TO KNOW

Attachment Unit Interface (AUI)
A physical and logical interface defined in the original IEEE 802.3 standard for 10BASE5 Ethernet and the previous DIX standard.

Legacy
An old computer system or application program that continues to be used because the owner does not want to replace or redesign it.

2b. 10Base5

Also known as Thicknet, 10Base5 uses a physical and logical bus with AUI connectors, 10 Mbps baseband technology, and coaxes up to 500 meters in length. You can extend multiple cable segments up to a total of 2,500 meters by using **repeaters** and 1,024 users for all segments. 10Base5 is a legacy network technology.

TERM TO KNOW

Repeater
A Layer 1 device that regenerates signals to mitigate the effects of attenuation.

2c. 10BaseT

This is 10 Mbps using Category 3 UTP or higher wiring. Unlike on 10Base2 and 10Base5 networks, each device must connect into a hub or switch, and you can have only one host per segment or wire. It uses an RJ-45 connector (8-pin modular connector) with a physical star topology and a logical bus. 10BaseT is a legacy network technology.

2d. 802.3u

Fast Ethernet supports speeds of 100 Mbps and is compatible with 802.3 Ethernet because they share the same physical characteristics. Fast Ethernet and Ethernet use the same **maximum transmission unit (MTU)** and the same MAC mechanisms, and they both preserve the frame format that is used by 10BaseT Ethernet. Basically, Fast Ethernet is just based on an extension of the IEEE 802.3 specification, and because of that, it offers an increased speed that is 10 times that of 10BaseT.

TERM TO KNOW

Maximum Transmission Unit (MTU)

The largest amount of data carried by a single packet of a given networking protocol.

3. Expanded IEEE Ethernet 802.3 Standards

3a. 100BaseTX (IEEE 802.3u)

100BaseTX, most commonly known as Fast Ethernet, uses EIA/TIA Category 5, 5e, or 6 and UTP two-pair wiring. It allows for one user per segment up to 100 meters long (328 feet) and uses an RJ-45 connector with a physical star topology and a logical bus.

3b. 100BaseFX (IEEE 802.3u)

Uses 62.5/125-micron multimode fiber cabling up to 412 meters long and point-to-point topology. It uses ST and SC connectors, which are media-interface connectors.

3c. 1000BaseCX (IEEE 802.3z)

Copper twisted-pair called twinax (a balanced coaxial pair) that can run only up to 25 meters and uses a special 9-pin connector known as the High-Speed Serial Data Connector (HSSDC).

3d. 1000BaseT (IEEE 802.3ab)

Category 5, four-pair UTP wiring, and up to 100 meters long (328 feet).

3e. 1000BaseTX

Category 5, two-pair UTP wiring up to 100 meters long (328 feet). Not used and has been replaced by Category 6 cabling.

3f. 1000BaseSX (IEEE 802.3z)

The implementation of Gigabit Ethernet runs over multimode fiber-optic cable instead of copper twisted-pair cable and uses a short wavelength laser. Multimode fiber (MMF), using 62.5- and 50-micron cores, utilizes an 850 nanometer (nm) laser and can go up to 220 meters with 62.5-micron cores and 550 meters with 50-micron cores.

3g. 1000BaseLX (IEEE 802.3z)

Single-mode fiber that uses a 9-micron core, 1,300 nm laser, and can go from 3 km up to 10 km.

3h. 10GBaseT

10GBaseT is a standard created by the IEEE 802.3an committee to provide 10 Gbps connections over conventional UTP cables (Category 5e, 6, 6A, or 7 cables). 10GBaseT allows the conventional RJ-45 used for Ethernet LANs. It can support signal transmission at the full 100-meter distance specified for LAN wiring. If you need to implement a 10 Gbps link, this is the most economical choice.

3i. 10GBaseSR

An implementation of 10 Gigabit Ethernet that uses short-wavelength lasers at 850 nm over multimode fiber. It has a maximum transmission distance of between 2 and 300 meters (990 feet) depending on the size and quality of the fiber.

3j. 10GBaseLR

An implementation of 10 Gigabit Ethernet that uses long-wavelength lasers at 1310 nm over single-mode fiber. It also has a maximum transmission distance between 2 meters and 10 km, or 6 miles, depending on the size and quality of the fiber.

3k. 10GBaseER

An implementation of 10 Gigabit Ethernet running over single-mode fiber that uses extra-long-wavelength lasers at 1,550 nm. It has the longest transmission distances possible of all the 10 Gigabit technologies: anywhere from 2 meters up to 40 km, again, depending on the size and quality of the fiber used.

3l. 10GBaseSW

10GBaseSW, as defined by IEEE 802.3ae, is a mode of 10GBaseS for MMF with an 850 nm laser transceiver and a bandwidth of 10 Gbps. It can support up to 300 meters of cable length.

3m. 10GBaseLW

10GBaseLW is a mode of 10GBaseL supporting a link length of 10 km on standard single-mode fiber (SMF) (G.652). This media type is also designed to connect to SONET equipment.

3n. 10GBaseEW

10GBaseEW is a mode of 10GBaseE supporting a link length of up to 40 km on SMF based on G.652 using optical-wavelength 1,550 nm. This is another media type designed to connect to SONET equipment.

EXAMPLE The table below summarizes the cable types.

Ethernet Name	Cable Type	Maximum Speed	Minimum Transmission Distance	Notes
10Base5	Coax	10 Mbps	500 meter per segment	Also called Thicknet, this cable type uses vampire taps to connect devices to cable.
10Base2	Coax	10 Mbps	185 meter per segment	popular implementation of Ethernet over coax.
10BaseT	UTP	10 Mbps	100 meter per segment	One of the most popular network cabling schemes.
100BaseTX	UTP, STP	100 Mbps	100 meter per segment	Two pairs of Category 5 UTP.
100Base	Fiber	10 Mbps	Varies (ranges from 500 meter to 2,000 meters)	Ethernet over fiber optics to the desktop.
10BaseFL	MMF	100 Mbps	2,000 meters	Mbps Ethernet over fiber optics.
100BaseFX	MMF	1000 Mbps	100 meters	Four pairs of Category 5 or higher.
1000BaseT	UTP	1000 Mbps	100 meters	Two pairs of Category 6 or higher.
1000BaseTX	MMP	1000 Mbps	550 meters	Uses SC fiber connectors. Max length depends on fiber size.
1000BaseSX	Balance, shielded copper	1000 Mbps	25 meters	Uses a special connector, the HSSDC.
1000BaseCX	MMF & SMF	1000 Mbps	550 meters multimode/ 2,000 meters single mode	Uses a longer wavelength laser than 1000BaseSX. Uses SC and LC connectors.
1000BaseLX	UTP	10 Mbps	100 meters	Connects to the network like a Fast Ethernet link using UTP.
10GBaseT	UTP	10 Mbps	400 meters	850 nm laser. Max length depends on fiber size and quality.
10GBaseLR	SMF	10 Mbps	10 meters	1,310 nm laser. Max length depends on fiber size and quality.
10GBaseER	SMF	10 Mbps	40 meters	1,550 nm laser. Max length depends on fiber size and quality.
10GBaseSW	MMF	10 Mbps	400 meters	850 nm laser transceiver.

10GBaseLW	SMF	10 Mbps	10 meters	Typically used with SONET.
10GBaseEW	SMF	10 Mbps	40 meters	1,550 nm optical wavelength.

IN CONTEXT

REAL WORLD SCENARIO

Deploy the Appropriate Wired Connectivity Standard

You have been tasked with installing wiring to handle the new networking technologies of 1000 Mbps to the desktop and Voice-over IP (VoIP). You will use 10 Gbps between the access switches and the core switches. What cabling do you consider installing in order to accomplish this in a cost-effective manner?

First, you need to verify your distances. As this will not include any wireless stations, you need to double-check the distances to each station and make sure the phone is within 100 meters (or closer) for connectivity to your access switches.

Once you have your distances verified at 100 meters or less, you can use UTP wiring to the stations and phones and possibly even connect the stations into the back of the phones. Most phones have switches included, so this means you only need to run one Category 5, or better, 1000BaseT, four-pair cable to each cubicle or office.

For your connections from your access switches to your core switches, you can use 10GbaseT if your runs are 100 meters or less, or you can use 10GbaseSR, which allows runs up to 400 meters using multimode fiber.

SUMMARY

In this lesson, you learned about **Ethernet at the physical layer**. This included some basic facts about various Ethernet standards including **IEEE 802.3 standards**. Finally, you learned about **expanded IEEE standards**. In the next lesson, we will begin to explore various types of network devices.

Source: This content and supplemental material has been adapted from CompTIA Network+ Study Guide: Exam N10-007, 4th Edition. Source Lammle: CompTIA Network+ Study Guide: Exam N10-007, 4th Edition - Instructor Companion Site (wiley.com)

TERMS TO KNOW

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Repeater

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