Physical Layers for Ethernet

In this lesson, we'll look at various types of physical layers and their limitations and benefits to Ethernet.

We'll cover the following

Several physical layers have been defined for Ethernet networks.

10Base5

The first type of physical layer, usually called **10Base5**, provided 10 Mbps over a thick coaxial cable. The characteristics of the cable and transceivers that were used then enabled the utilization of 500 meter long segments. A 10Base5 network can also include repeaters between segments.

10Base2

The second type of physical layer was **10Base2**. 10Base2 used a thin coaxial cable that was easier to install than the 10Base5 cable but could not be longer than 185 meters.

10BaseF

A 10BaseF type of physical layer was also defined to transport Ethernet over point-to-point optical links.

10BaseT

Twisted Pairs

The major change to the physical layer was the support of twisted pairs in the 10BaseT specification. Twisted pair cables are traditionally used to support the telephone service in office buildings. Most office buildings today are equipped with structured cabling. Several twisted pair cables are installed between any room and a central telecom closet per building or per floor in large buildings. These telecom closets act not only as concentration points for the telephone service but also for LANs.

Changes to Ethernet

The introduction of the twisted pairs led to two major changes to Ethernet. Let’s discuss each.

Change in Topology

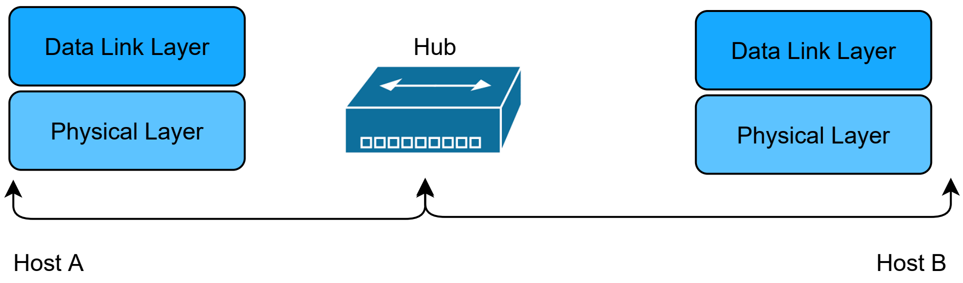
The first change concerns the physical topology of the network. 10Base2 and 10Base5 networks are shared buses, the coaxial cable typically passes through each room that contains a connected computer. A 10BaseT network, however, is a **star-shaped network**. All the devices connected to the network are attached to a twisted pair cable that ends in the telecom closet. From a maintenance perspective, this is a major improvement. The cable is a weak point in 10Base2 and 10Base5 networks. Any physical damage on the cable broke the entire network and when such a failure occurred, the network administrator had to manually check the entire cable to detect where it was damaged. With 10BaseT, when one twisted pair is damaged, only the device connected to this twisted pair is affected and this does not affect the other devices.

Introduction of Ethernet Hubs

The second major change introduced by 10BaseT was that is was impossible to build a 10BaseT network by simply connecting all the twisted pairs together.

All the twisted pairs must be connected to a relay that operates in the physical layer. This relay is called an **Ethernet hub**. A hub is thus a physical layer relay

that receives an electrical signal on one of its interfaces, regenerates the signal and transmits it over all its other interfaces. Some hubs are also able to convert the electrical signal from one physical layer to another, such as a 10BaseT to 10Base2 conversion.



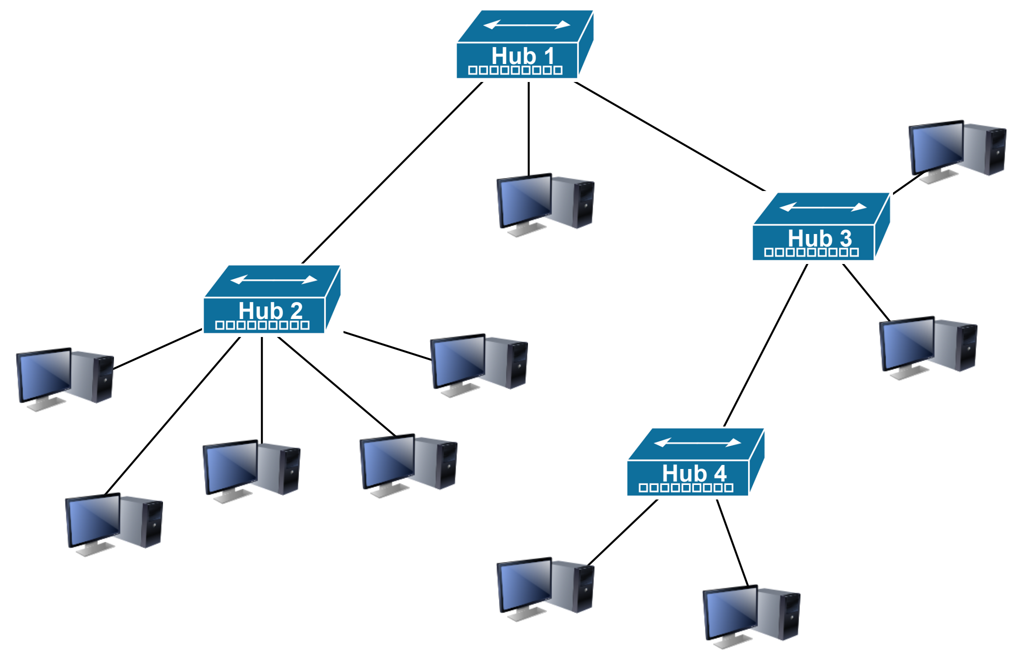
Ethernet hubs in the reference model

Computers can directly be attached to Ethernet hubs. Ethernet hubs themselves can be attached to other Ethernet hubs to build a larger network.

However, some important guidelines must be followed when building a complex network with hubs.

1. First, **the network topology must be a tree**. As hubs are relays in the physical layer, adding a link between Hub 2 and Hub 3 in the network below would create an electrical shortcut that would completely disrupt the network. This implies that there cannot be any redundancy in a hub-based network. A failure of a hub or a link between two hubs would partition the network into two isolated networks.

2. Second, as hubs are relays in the physical layer, collisions can happen and must be handled by CSMA/CD as in a 10Base5 network. This implies that the maximum delay between any pair of devices in the network can't be longer than the 51.2 microseconds, slot time. If the delay is longer, collisions between short frames may not be correctly detected. This **constraint limits the geographical spread of 10BaseT networks containing hubs**.



A hierarchical Ethernet network composed of hubs

Fast Ethernet

In the late 1980s, 10 Mbps became too slow for some applications and network manufacturers developed several LAN technologies that offered higher bandwidth, such as the 100 Mbps FDDI LAN that used optical fibers.

As the development of 10Base5, 10Base2 and 10BaseT had shown that Ethernet could be adapted to different types of physical layers, several manufacturers started to work on 100 Mbps Ethernet and convinced IEEE to standardize this new technology that was initially called **Fast Ethernet**. Fast Ethernet was designed under two constraints:

1. First, Fast Ethernet had to support twisted pairs. Although it was easier from a physical layer perspective to support higher bandwidth on coaxial cables than on twisted pairs, coaxial cables were a nightmare from deployment and maintenance perspectives.
2. Second, Fast Ethernet had to be perfectly compatible with the existing 10 Mbps Ethernets to allow Fast Ethernet technology to be used initially as a backbone technology to interconnect 10 Mbps Ethernet networks. This forced fast Ethernet to use exactly the same frame format as 10 Mbps Ethernet. This implied that the minimum Fast Ethernet frame size remained at 512 bits. To preserve CSMA/CD with this minimum frame

> remained at 512 bits. To preserve CSMA/CD with this minimum frame size and 100 Mbps instead of 10 Mbps, the duration of the slot time was
>
> decreased to 5.12 microseconds, which implies that the maximum distance between two end stations was also reduced.

The evolution of Ethernet did not stop. In 1998, the IEEE published the first standard to provide Gigabit Ethernet over optical fibers. Several other types of physical layers were added afterward. The 10 Gigabit Ethernet standard appeared in 2002.

Work is ongoing to create faster ethernet standards. The table below lists the main Ethernet standards. A more detailed list may be found here.

Standard	Comments
10Base2	Thick coaxial cable, 500m
10Base5	Thin coaxial cable, 185m
10BaseT	Two pairs of category 3+ UTP
10Base-F	10 Mb/s over optical fiber
100Base-Tx	Category 5 UTP or STP, 100 m maximum
1000Base-CX	Two multimode optical fiber, 2 km maximum
100Base-FX	Two multimode or single mode optical fibers with lasers
1000Base-SX	Two pairs shielded twisted pair, 25m maximum
40-100 Gbps	Optical fiber but also Category 6 UTP

Quick Quiz!

1 Which of the following is an advantage of 10BaseT?

A) Maximum distance between stations was reduced compared to Ethernet

B) It has fewer points of failure than 10Base5, 10Base2, and 10BaseF and so is more reliable

C) The frame size was increased from Ethernet

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In the next lesson, we'll study Ethernet switches.