8
Media Types - Connecting Everything Together

While you are probably more than aware that most networks are wired, you should note that not every wiring standard is the same. If they were, we would only need the one. As it stands, there are numerous different standards still in operation, from legacy cables running at 10 Mbps to high-speed fiber operating at more than 40 Gbps. As a network engineer, it is imperative that we understand the use cases and limitations of the various different cabling options available to us.

This chapter will follow the progression of cabling from coaxial cables, through to twisted pair cables, to fiber optic cables, all while explaining the characteristics of each, including their connectors and their uses.

The following topics will be covered in this chapter:

- Understanding coaxial cables and their types
- Understanding twisted pair cables and their types
- Understanding fiber optic cables and their types

Technical requirements

There are no technical requirements for this chapter.

Understanding coaxial cables and their types

I remember when I was first learning about networking in 2000 and coaxial cables were introduced. I thought to myself, *nobody is going to use that for much longer*. For me, it was dated technology that was being replaced. Yet, it's still here. It has stood the test of time and is used in networking, audio, and video.

A coaxial cable consists of a copper core surrounded by an insulator. This, in turn, is surrounded by a woven copper shield that's encased in an outer plastic jacket. This can be seen in the following diagram:

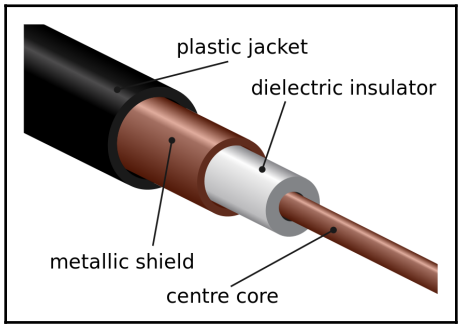

Figure 8.1: Coaxial cable

The preceding diagram can be found at `https://en.wikipedia.org/wiki/Coaxial_cable#/media/File:Coaxial_cable_cutaway.svg`. It is licensed under Creative Commons CC BY 3.0: `https://creativecommons.org/licenses/by/3.0/deed.en`.

One of the issues with using copper to transmit data is that it gives off an electromagnetic field and can also be impacted by external electromagnetic fields generated by other nearby objects, including other network cables. Put simply, when voltage is applied to a conductive cable, an electromagnetic field is generated, which can affect other electrical systems in close proximity. When it does this, it is referred to as **electromagnetic interference** (**EMI**).

EMI can be a major problem with networks using a copper cable, and hence how the cables are placed has to be thought out carefully. Major sources of EMI that can affect your network include fluorescent lights and elevator machinery. The woven copper shield acts to prevent these magnetic fields. It helps to keep the internal data signal within the confines of the cable and provides protection from external electromagnetic fields.

It should be noted that the shield will not protect the cable 100%, and some leakage and interference with the data may take place.

There are two main types of coaxial cable in use in networking. These are 10base5 and 10base2. These names follow a naming convention that roughly follows this syntax:

<speed><signal type><medium>

From this, we can see that both have a speed of 10 Mbps and use the baseband signaling type. Baseband utilizes the available bandwidth for one signal. Another term you will hear is broadband. Broadband splits the available bandwidth between multiple signals.

Let's take a closer look at the two coaxial cable types individually.

10base5 coaxial cable

10base5 is referred to as thicknet. It utilizes RG-8 cabling and can be a maximum of 500 m in length. If you were to make this any longer, the attenuation, or degradation of the signal, would be so great that it would be unusable. To connect to the cable devices, it uses a vampire tap, as shown in the following picture:

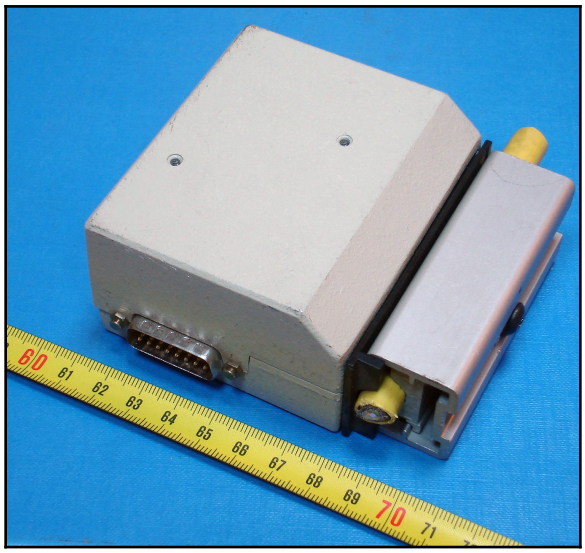

Figure 8.2: Vampire tap with thicknet cable

The preceding image can be found at `https://en.wikipedia.org/wiki/Vampire_tap#/media/File:ThicknetTransceiver.jpg`. It is under the Creative Commons CC BY-SA 2.5: `https://creativecommons.org/licenses/by-sa/2.5/`.

The vampire tap literally bites into the cable to make a connection. This is clearly depicted in the following picture:

Figure 8.3: Vampire tap showing bite marks

The preceding image can be found at `https://en.wikipedia.org/wiki/Vampire_tap#/media/File:VampireTap.jpg`. It is under the Creative Commons CC BY-SA 2.5: `https://creativecommons.org/licenses/by-sa/2.5/`.

An alternative to the vampire tap is the N-connector, as shown in the following picture:

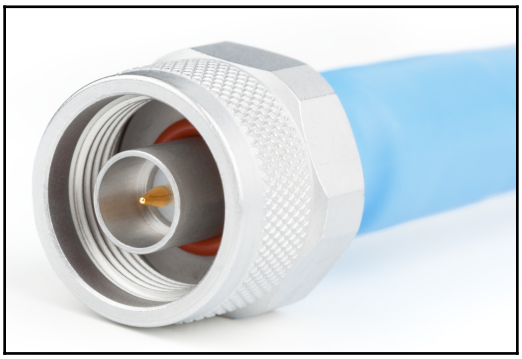

Figure 8.4: A male N-connector

The preceding image can be found at `https://commons.wikimedia.org/wiki/File:Male_type_N_connector.jpg`. It is under the Creative Commons CC BY-SA 3.0: `https://creativecommons.org/licenses/by-sa/3.0/deed.en`.

As its name implies, the thicknet cable is a thick cable, which means it's not very flexible. This makes it difficult to handle, but it is capable of handling up to 100 devices. It should be noted, however, that coaxial cables are usually found in bus topologies (`Chapter 5`, *Network Topologies – Mapping It All Out*) and are half duplex, so the more devices there are, the more contention there will be.

Now, let's learn about the 10base2 coaxial cable.

10base2 coaxial cable

In contrast, 10base2 is known as **thinnet**. It utilizes RG-58 cabling and can be a maximum of 185 m in length. For thinnet, we would use a combination of BNC connectors and T-piece connector. The following picture shows a BNC connector:

Figure 8.5: BNC connector

The preceding image can be found at `https://en.wikipedia.org/wiki/BNC_connector#/media/File:BNC_connector_50_ohm_male.jpg`. The picture is by Swift.Hg. Licensed under Creative Commons CC BY-SA 3.0: `https://creativecommons.org/licenses/by-sa/3.0/`.

A section of the cable has BNC connectors at either end that connect to the T-piece. The T-piece is connected to either another section of the cable or a terminator (as shown in the following picture) and a network card. The terminator would be placed at the T-piece at either end of the bus topology and would kill the signal to prevent signal bouncing. Since the thinnet is thinner than the thicknet, it is a lot more flexible:

Figure 8.6: T-piece connectors left and center, and [green] terminators

The preceding picture can be found at `https://en.wikipedia.org/wiki/BNC_connector#/media/File:BNC-Technik.jpg`. The picture is by Romantiker. It is licensed under Creative Commons CC BY-SA 3.0 `https://creativecommons.org/licenses/by-sa/3.0/`.

Coaxial cables are relatively cheap unless you're looking at a large installation. It is simple to install, but a single break or ill-fitting connection can bring the whole network down. Finally, while it is pretty resilient to EMI, it has the potential to be eavesdropped on relatively easily, so protecting sensitive data has to be taken into consideration.

Understanding twisted pair cables and their types

Perhaps the most common type of network cable in use currently, twisted pair cables are, in my experience, possibly the cables that are mislabeled the most. When showing people a twisted pair cable, I've often heard it being called a Cat 5 cable or an RJ-45 cable. As you will see in this section, the Cat 5 cable is a variant of twisted pair cabling, while RJ-45 refers to the type of connector that's used with a twisted pair cable.

I would like to start off by talking about the characteristics that all twisted pair cables have in common. Firstly, each cable is made of eight inner copper wires that carry a voltage. These eight wires are broken down into four pairs, and the wires in each pair are twisted around their siblings. Each wire in a pair carries an electrical signal that is opposite to other. By twisting the wires of the pairs together, you reduce the electromagnetic field and reduce the prospect of cross talk. Cross talk is when the signal from one wire affects the signal in another. The other characteristic they have in common is the maximum cable length, which is 100 m.

The speed of twisted pair cables is dependent on the physical characteristics of the cable. The following table shows the speed of the common twisted pair categories:

Category	**Nomenclature**	**Speed**
Cat 3	10baseT	10 Mbps
Cat 5	100baseT	100 Mbps
Cat 5e	1000baseT	1,000 Mbps/1 Gbps
Cat 6	1000baseT	1,000 Mbps/1 Gbps (only to 55 m)
Cat 6a	10GbaseT	10 Gbps
Cat 7	10GbaseT	10 Gbps
Cat 7a	10GbaseT	10 Gbps

Regardless of the type of twisted pair cable being used, each of them will be terminated by an RJ-45 connector (as shown in the following picture), also known as an 8P8C modular plug, which would connect to an RJ-45 port:

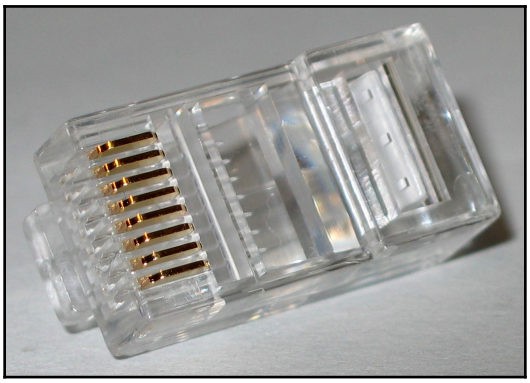

Figure 8.7: RJ-45 connector

The preceding picture can be found at `https://en.wikipedia.org/wiki/Modular_connector#/media/File:Uncrimped_rj-45_connector_close-up.jpg`. This picture is under the public domain.

Exam tip: You may see RJ-8 mentioned in the answers to some exam questions. Although this is similar to RJ-45 in design, it is used for telephony/modems and only has four wires (two pairs).

Now, let's take a look at the different types of twisted pair cables.

Unshielded twisted pair

The **unshielded twisted pair** (**UTP**) cable consists solely of the wires and their insulators, as well as the outer sheath. This can be seen in the following picture:

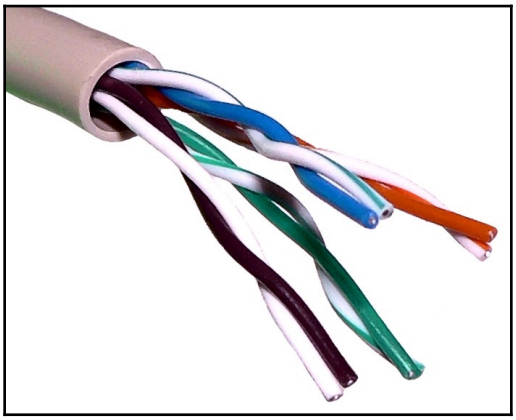

Figure 8.8: UTP cable

The preceding picture can be found at `https://en.wikipedia.org/wiki/Twisted_pair#/media/File:UTP_cable.jpg`. This picture is under the public domain.

Now, let's learn about the **shielded twisted pair** (**STP**) cable.

STP

This cable is similar to UTP but the wires and their insulators are surrounded by a foil shield. The foil helps reduce EMI but also reduces flexibility. This can be seen in the following picture:

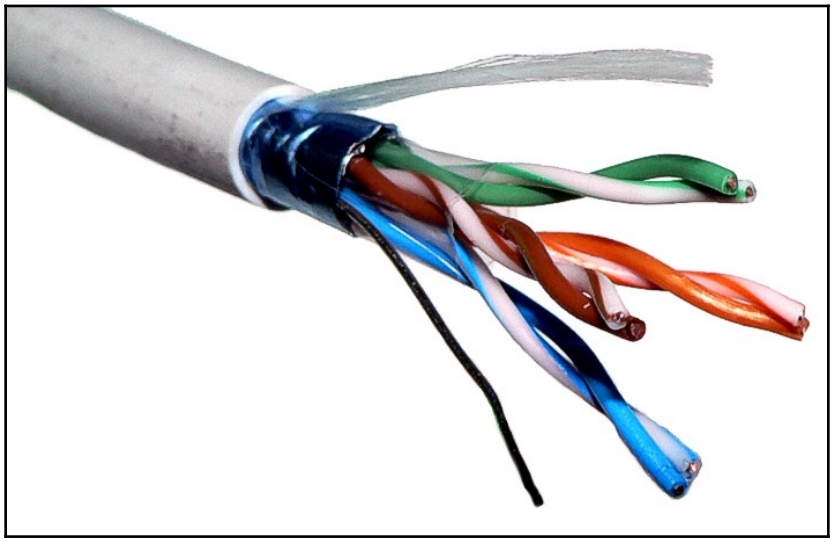

Figure 8.9: STP cable

The preceding picture can be found at `https://en.wikipedia.org/wiki/Twisted_pair#/media/File:FTP_cable3.jpg`. This picture is under the public domain.

Note the grounding wire just below the blue/blue-white pair and the foil shielding surrounding all the inner wires.

Screened twisted pair

This cable, also known as an ScTP cable, takes the concept of STP and wraps each pair in foil to further improve EMI reduction. This can be seen in the following picture:

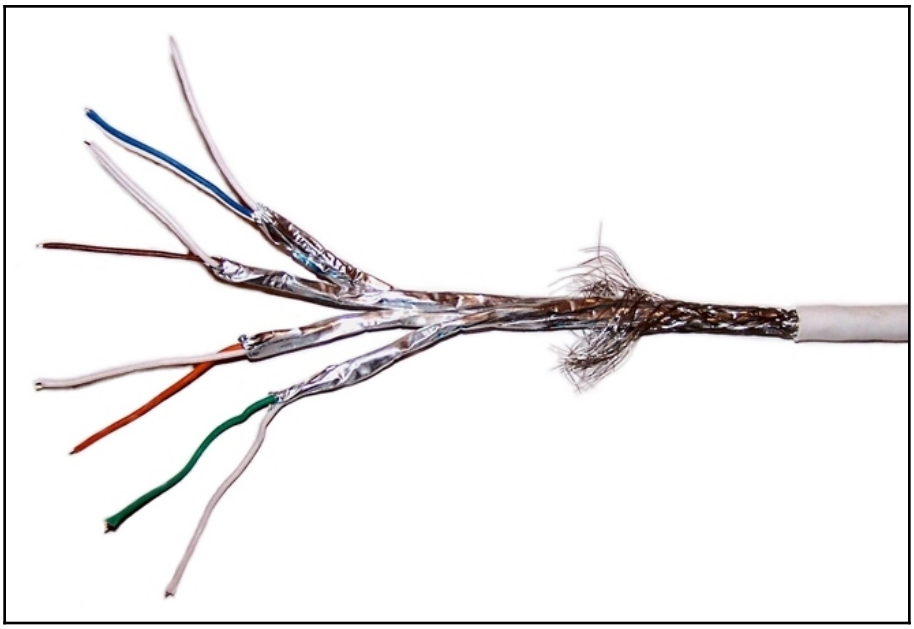

Figure 8.10: ScTP cable

The preceding picture can be found at `https://en.wikipedia.org/wiki/Twisted_pair#/media/File:S-FTP_CAT_7.jpg`. This picture is under the public domain.

Now that we have looked at the different types of twisted pair cables, let's learn about the plenum outer coating present in them.

Understanding the plenum coating

Each of the preceding cables can have a plenum outer coating. The term plenum refers to the floor space the cable is being used in. Plenum cabling runs through **heating, ventilation, and air-conditioning** (**HVAC**) conduits. This prevents the release of toxic fumes in the event of the cabling being burned.

Power over Ethernet

I would like to finish off this section by briefly mentioning **Power over Ethernet** (**PoE**). Since a twisted pair cable is basically a conduit for electricity to travel through, it can also be used to power devices that are not near a traditional power source. Obviously, there are limitations as to how much power these devices can draw based on how much power can be conducted by the cable, but they have some obvious advantages for low powered devices such as **Voice over IP** (**VoIP**) phones and **wireless access points** (**WAP**).

Moving forward, let's understand the wiring standards that need to be followed while using these cables.

Following wiring standards

To ensure compatibility when cabling between devices, a set of wiring standards need to be utilized. These are referred to as TIA-568A (see the following diagram) and TIA-568B (see the diagram that follows) and are used with an RJ-45 connector. An RJ-45 connector contains eight pins that bite into one of the wires inside the twisted pair cable. These pins are numbered from 1-8. By following these standards, you are ensuring that a transmitting pin on one device is connected to a receiving pin on the destination device:

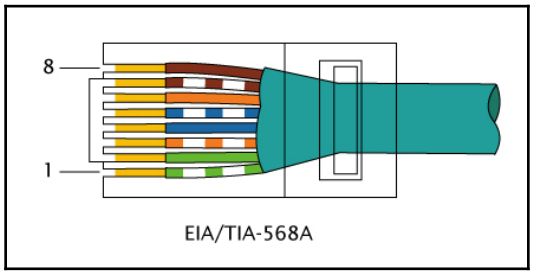

Figure 8.11: TIA-568A

The preceding diagram can be found at `https://en.wikipedia.org/wiki/Modular_connector#/media/File:RJ-45_TIA-568A_Left.png`. This diagram is under the public domain.

You may find that you use TIA-568A on both ends of the cable or that one end may be wired using TIA-568B:

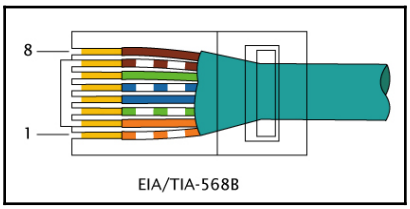

Figure 8.12: TIA-568B

The preceding image can be found at `https://en.wikipedia.org/wiki/Modular_connector#/media/File:RJ-45_TIA-568B_Left.png`. This image is under the public domain.

The following table shows the details of pin/cable pair mapping for the two standards:

Pin	TIA-568a colors	TIA-568B colors
1	Green/white	Orange/white
2	Green	Orange
3	Orange/white	Green/white
4	Blue	Blue
5	Blue/white	Blue/white
6	Orange	Green
7	Brown/white	Brown/white
8	Brown	Brown

There are three different combinations that a twisted pair cable can be wired in. These are straight-through, crossover, and rollover.

Straight-through cable

A straight-through cable is wired using the TIA-568B standard on both ends. The purpose of a straight-through cable is to connect dissimilar devices, for example, a PC to a switch, a PC to a hub, and a switch to a router. A common misconception is that when we use the term *dissimilar devices*, we are focusing on the device as a whole, while in reality we are focusing on which pins they transmit and receive on. As shown in the following diagram, pin 1 is connected to pin 1, pin 2 is connected to pin 2, and so on:

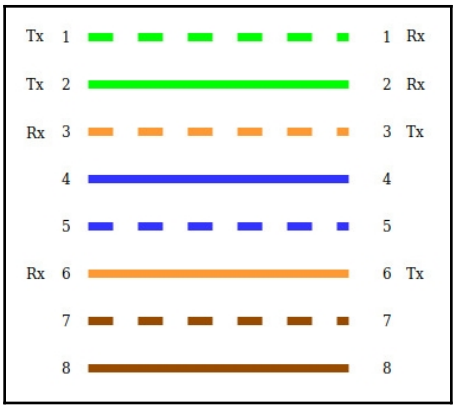

Figure 8.13: Straight-through cable

The next combination is the crossover cable.

Crossover cable

A crossover cable is used when connecting two similar devices together. Similar devices would be a PC to a PC, a switch to a switch, a router to a router, and a PC to a router. The last one on the list is a good example of how the similarity of devices is based on transmit and receive pins. While crossover cables exist, it is highly unlikely that you will use one. The simple reason for this is that most modern network cards are capable of identifying whether a pin should be used to transmit or receive. As shown in the following diagram, with a crossover cable, pin 1 is connected to pin 3, while pin 2 is connected to pin 6:

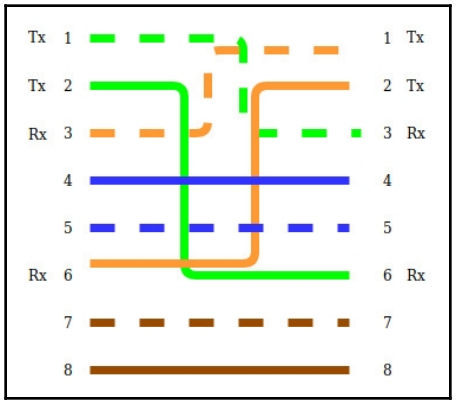

Figure 8.14: Crossover cable

The next combination is the rollover cable.

Rollover cable

A rollover cable is used to connect to the console port of a device to allow you to manage or configure it. The wiring varies depending on the manufacturer, but for Cisco devices, a crossover cable's pin 1 is connected to pin 8; pin 2 is connected to pin 7, and so on. This can be seen in the following diagram:

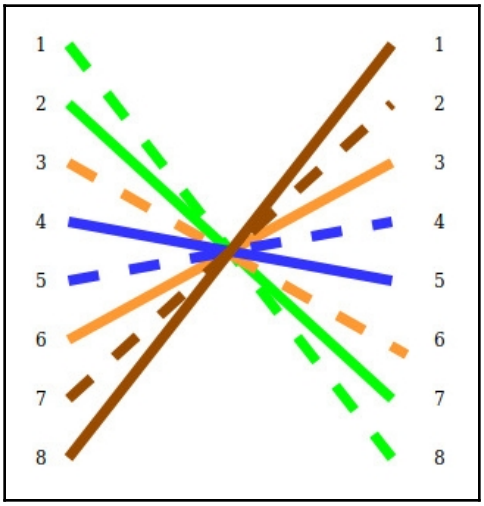

Figure 8.15: Rollover cable

In this section, we have learned about the various types of twisted pair cables and their wiring standards. In the next section, we will introduce you to fiber optic cables.

Understanding fiber optic cables and their types

As we mentioned previously, both coaxial and twisted pair cables use a copper wire to transmit a signal in the form of voltage. In contrast, fiber optic cables use a signal made up of light. The light is generated by either an LED or a laser. Fiber optic networks provide high speed, long-distance connectivity that is resistant to EMI.

A fiber optic cable consists of either a single glass strand or multiple glass strands surrounded by an outer jacket, as shown in the following diagram. Each glass strand comprises a hollow central core that the light travels down and a glass cladding layer that prevents the light from escaping by reflecting it back into the core:

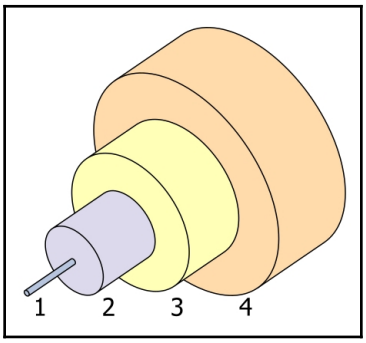

Figure 8.16: Fiber optic cable: 1) Core 2) Cladding 3) Buffer 4) Jacket

The preceding diagram can be found at `https://commons.wikimedia.org/wiki/File:Singlemode_fibre_structure.svg`. It is under the Creative Commons CC BY-SA 3.0 `https://creativecommons.org/licenses/by-sa/3.0/deed.en`.

Fiber optic cables can be either **single-mode fiber** (**SMF**) or **multi-mode fiber** (**MMF**). Let's go over these now.

SMF

SMF consists of glass strands with a very thin core that allows only one light signal (from a laser) to be transmitted at a time. SMF is used for high speed, long-distance networks. The following connectors can be used with SMF:

- D4
- Biconic
- E2000
- FC
- LC
- MTP
- MTRJ

- MU
- SC SCapc
- ST

To see what some of these connectors look like, go to `https://en.wikipedia.org/wiki/Optical_fiber_connector#/media/File:LC-optical-fiber-connector-hdr-0a.jpg` and `https://commons.wikimedia.org/wiki/File:ST-optical-fiber-connector-hdr-0a.jpg`.

MMF

MMF consists of glass strands with a larger core. By increasing the core size, the cable is capable of transmitting multiple light signals at once through the use of LEDs. The following connectors can be used with MMF:

- FC
- Biconic
- MTP
- SMA
- MTRJ
- SMC
- LC Duplex
- SC
- ST

To see what some of these connectors look like, go to `https://en.wikipedia.org/wiki/Optical_fiber_connector#/media/File:FCPC_002.jpg` and `https://en.wikipedia.org/wiki/Optical_fiber_connector#/media/File:MMF_optical.jpg`.

The following table shows the speeds of the various forms of fiber optic cabling:

Type	**Speed**	**Distance**	**Mode**
1000baseLX	1,000 Mbps/1 Gbps	5 km	SMF
1000baseSX	1,000 Mbps/1 Gbps	550 m	MMF
10GbaseLX4	10 Gbps	10 km	SMF
10GbaseER/EW	10 Gbps	22 km	SMF
10GbaseSR/W	10 Gbps	550 m	MMF

40GbaseSR	40 Gbps	150 m	MMF
100GbaseLR4	100 Gbps	10 km	SMF
100GbaseER4	100 Gbps	40 km	SMF
100GbaseSR10	100 Gbps	150 m	MMF
100GbaseSR4	100 Gbps	100 m	MMF

Exam tip: You may have noticed that some of the connectors can be used on both SMF and MMF. You may have also noticed there are a lot of connectors with names that are not so easy to remember. The way I treat fiber connectors in terms of the exam is simple. I know the likelihood of having a question that asks me to differentiate between two fiber connectors is low. Therefore, I remember what connectors are used for coaxial and twisted pairs, and whatever is left must be a fiber connector.

Summary

In this chapter, we concentrated on the physical connections between devices. We began this chapter by looking at what is, arguably, legacy cabling in the form of coaxial. We then moved on to the most common form of cabling in use today, that is, the twisted pair. We finished off this chapter by looking at fiber optic cables. For each of the cable types, we discussed the various different characteristics and connectors they have.

Through this chapter, you have learned how to identify the different cable types that are available to network engineers and the ability to choose the most appropriate cabling for your use. You also learned how to wire twisted pair cables in various formats. While you can obviously acquire this cabling off the shelf, every network engineer will need to make their own network cable at some point during their career.

In the next chapter, we will move on to the OSI model, a set of standards that cover networking from both the software and hardware sides of life. We will walk through the model and discuss the function of each layer of the model, as well as discuss some of the common protocols on each layer.