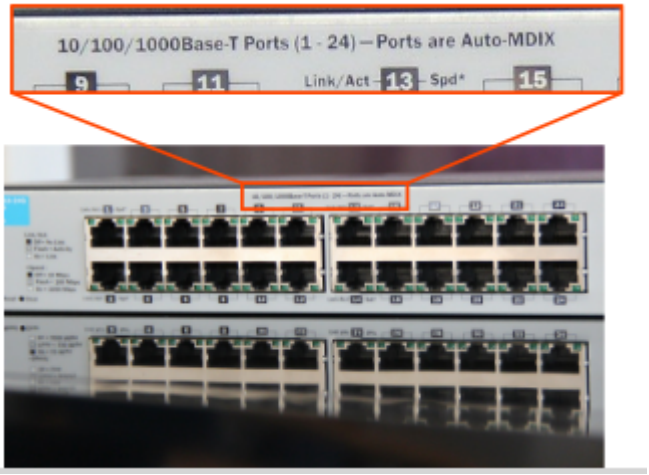
Interface and Cables

Interface and Cables

In this section we will cover interfaces & cables and how they work when connected to network devices.

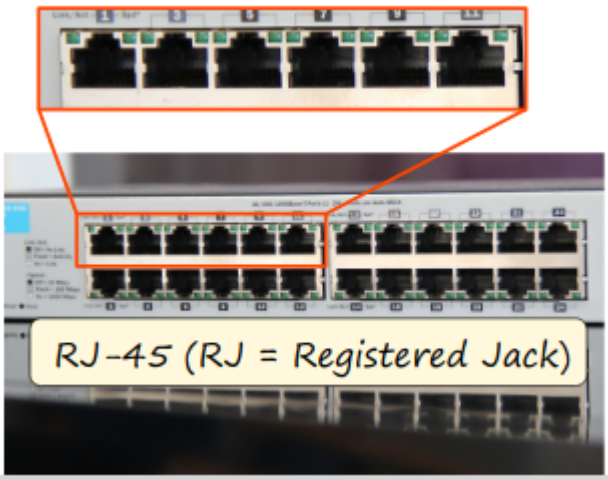
Wireless connections are also a part of networking which we will go through later in the course.

To begin with, we will look at the interface of a switch (**which has 24+ ports for end hosts to connect to**).

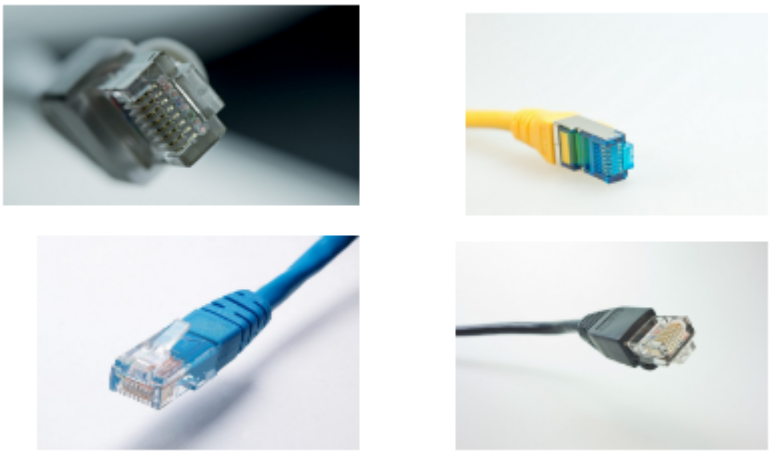


We will define these tags to understand what they do

Take a look at the shape of the the interface, your computer uses this to connect to a wired network. This port is known as a `RJ45` **(Registered Jack)**.



`RJ45` ports

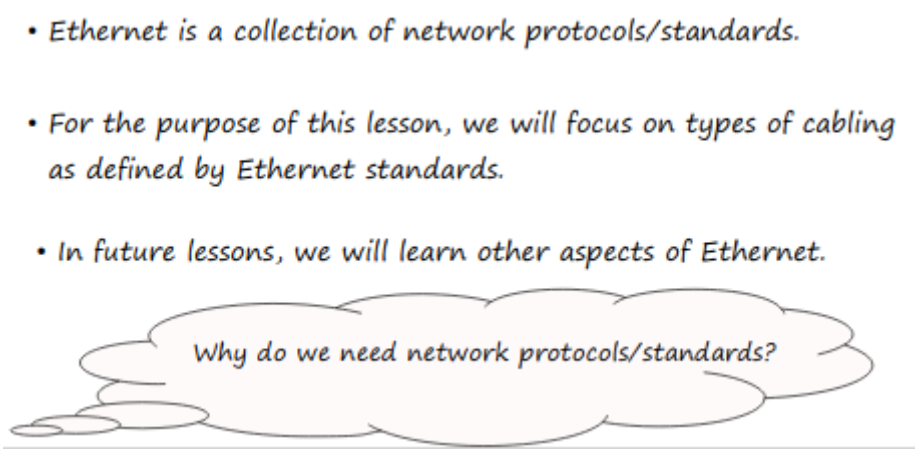


RJ45 connectors

The RJ45 is **used on the end of a copper-Ethernet cable**. There are other Ethernet cables that do not use copper wiring which we will discuss later.

Ethernet

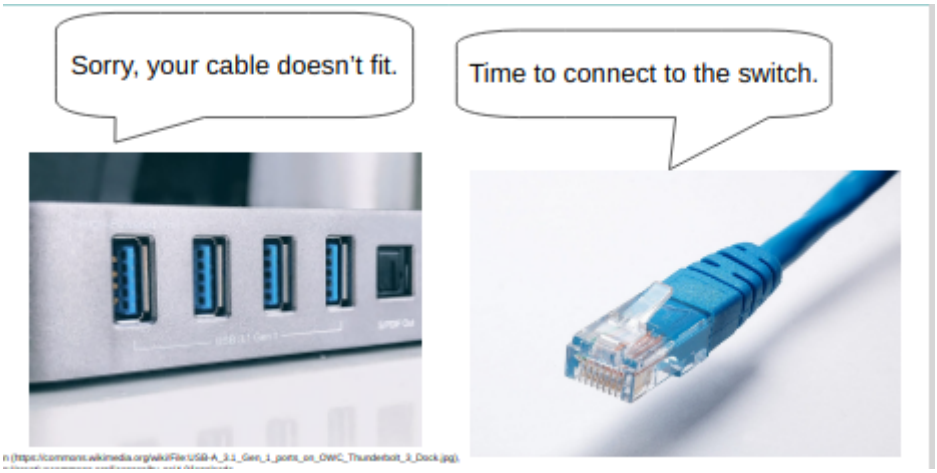
Ethernet is a **collection of network protocols & standards**. Because of this, Ethernet is **not defined by one singular protocol or standard**. For the **CCNA 200-301** course, we will look at the types of cables defined by Ethernet standards.



Network standards protocols help other computers communicate by using the **same protocol/standard** which the computers can understand even if they are using different languages / configuration / devices, etc.

The two can communicate and understand each other using Ethernet protocols/standards

The hardware for Ethernet cables are set to a universal standard, so you would not be able to apply it an incompatible device.

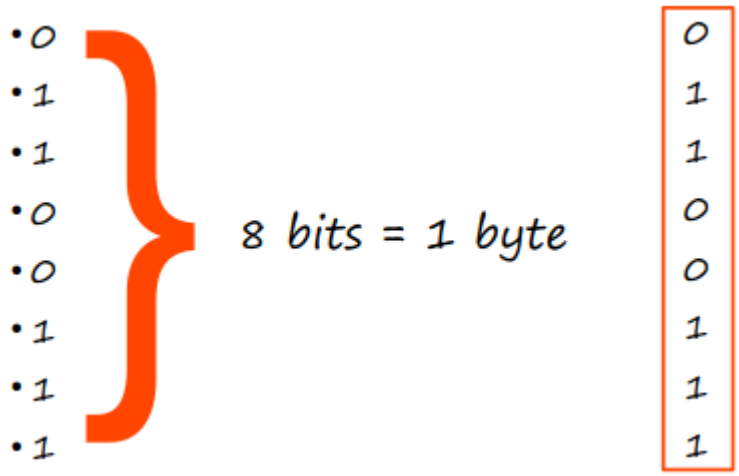


The `RJ45` will not be able to fit in the USB slot

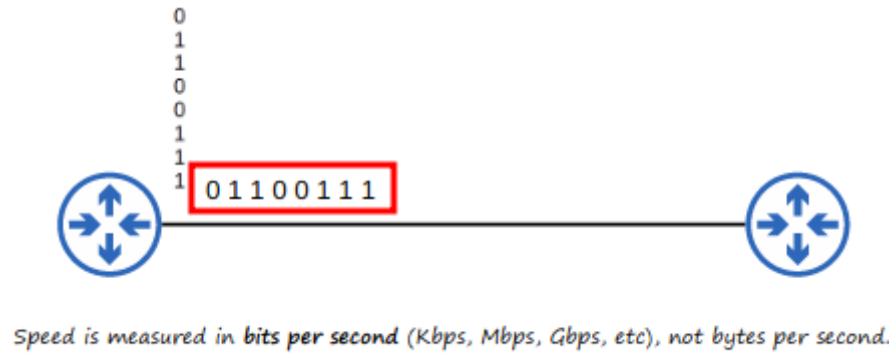
Manufacturers apply the universal standards to the hardware (ports, cables, connectors, etc), just how standards are applied to network IP addresses - different types of end hosts stick to the same networking rules.

Bits and Bytes

Connections between devices in a network operate at a set speed. The speed is measured in **bits per second (Bps)**.
So what is a bit? It is a **binary digit represented by a `0` or `1`**. *Computers, websites, operating systems, etc all work off from binary code*. **`8 bits` make up `1 byte`.**



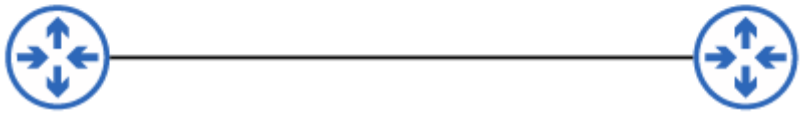
As mentioned before, bits are measured in *bits per second*. This is because when traffic/data is being sent across a network, it is sent across **one bit at a time**, *not one byte at a time*.



Traffic being sent across two routers

- 1 kilobit (Kb) = 1,000 bits
- 1 megabit (Mb) = 1,000,000 bits
- 1 gigabit (Gb) = 1,000,000,000 bits
- 1 terabit (Tb) = 1,000,000,000,000 bits

Decimal	
Value	SI
1000 10^{3}	kbit **kilobit**
1000^{2} 10^{6}	Mbit megabit
1000^{3} 10^{9}	Gbit gigabit
1000^{4} 10^{12}	Tbit terabit
1000^{5} 10^{15}	Pbit petabit
1000^{6} 10^{18}	Ebit exabit
1000^{7} 10^{21}	Zbit zettabit
1000^{8} 10^{24}	Ybit yottabit



Simple illustration of different network speeds.

Also remember **data on a hard drive is *measured in bytes***.

Ethernet Standards

Ethernet Standards are defined in the **IEEE (Institute of Electrical and Electronics Engineers) 802.3** standard in 1983.

If you see this image you will know that it will come with the Ethernet standards

We will look at the Ethernet standards for copper cables as well as fibre optic cables.

Speed	Common Name	IEEE Standard	Informal Name	Maximum Length
10 Mbps	Ethernet	802.3i	10BASE-T	100 m
100 Mbps	Fast Ethernet	802.3u	100BASE-T	100 m
1 Gbps	Gigabit Ethernet	802.3ab	1000BASE-T	100 m
10 Gbps	10 Gig Ethernet	802.3an	10GBASE-T	100 m

Study and understand the table. `BASE` *is baseband signalling,* `T` *is twisted pair (cables)*

We will look more into the physical cables and how they work.

UTP Cables

UTP (Unshielded Twisted Pair) cables are cables used to comply with Ethernet standards. They also protect against **EMI (Electromagnetic Interference)**.

We should note not all Ethernet standards use 8 wires

• Unshielded means they have **no metallic shield**. *This can make them vulnerable to electrical interference*.
• The twisted wires helps **prevent electrical interference**.
• The wires are twisted in pairs; in this picture there are **4 pairs**, meaning **8 cables**.

10BASE-T
100BASE - T
= 2 pairs (4 wires)

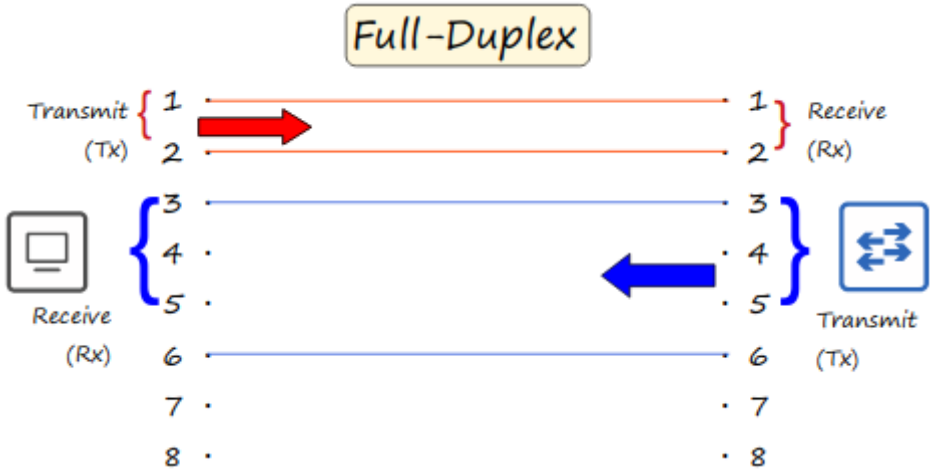
1000BASE-T
10GBASE-t
= 4 pairs (8 wires)

If we study the picture below we can see the different UTP cables use different amount of wires.

We will look deeper into `10BASE-T` & `100BASE-T` cables.

Full-Duplex

We will look at the connectivity between an end host and a switch. Imagine a scenario where we are connecting a *PC to a switch* with `10BASE-T` or `100BASE-T` cables. The numbers in the diagram represent the pins on the `RJ45` connector.



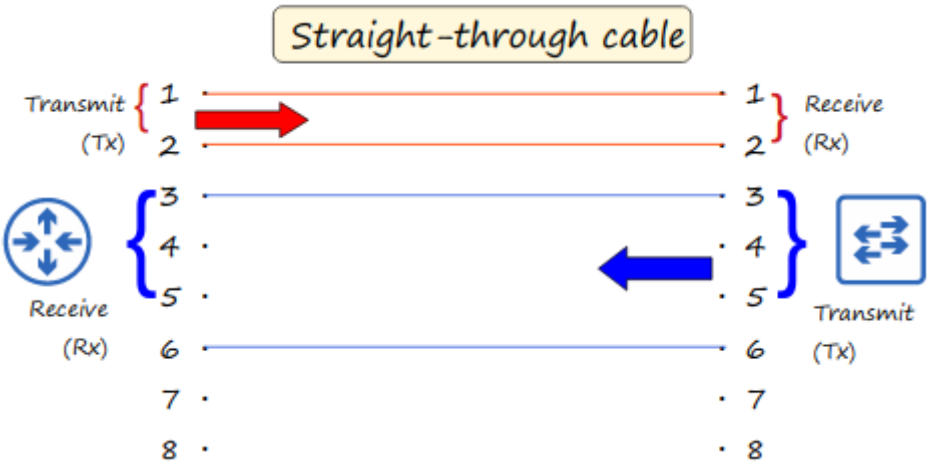
The lines are straight but the wires would be twisted together in the physical hardware

The PC (end host) will **transmit** data through **pins 1 & 2**, and the switch interface will **receive** the data through **pins 1 & 2**.
On the switch, **pins 3 & 6** are used to **transmit** the data, while the end host **receives** the data through **pins 3 & 6**.

This is a Full-Duplex transmission because **both devices can send & receive data at the same** time without any data collisions. This is achieved by using separate wires.

Straight-through

We will now look at the connectivity between a router and a switch, using `10BASE-T` or `100BASE-T` cables.



This also uses a Full-Duplex transmission

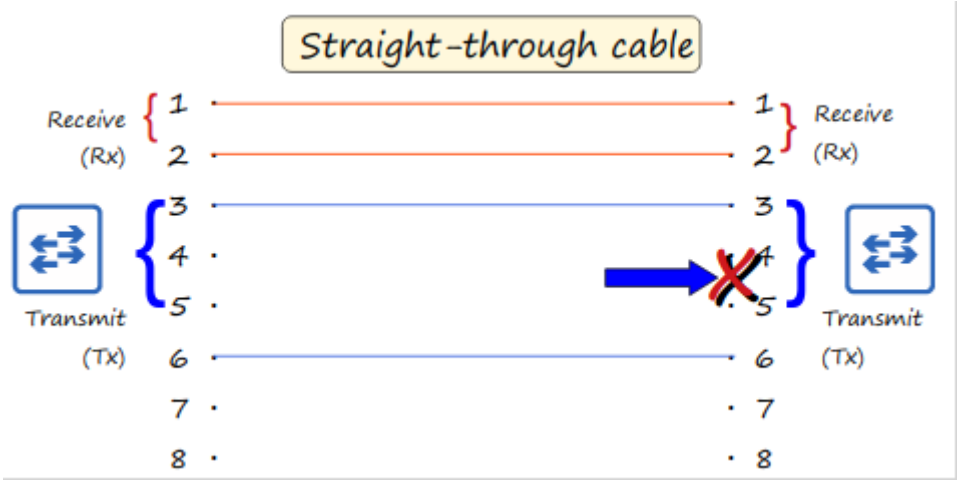
The router **transmits data on pins 1 & 2**, and **receives data through pins 3 & 6**.
The switch **receives data on pins 1 & 2**, and **transmits data through 3 & 6**.

These are also called **straight-through** cables **because the pins are connected to their matching numbers** *(pin 1 connects to pin 1, pin 2 connects to pin 2, etc)*.

Crossover cable

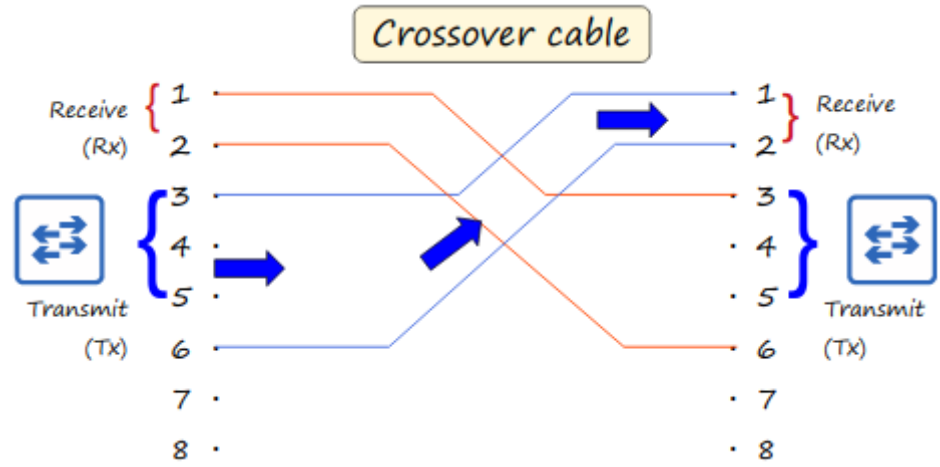
Sometimes we may want to connect two of the same type of network nodes together (IE, **two switches, two PCs, etc**).
We will look at how we can connect two switches that are the same, using `10BASE-T` or `100BASE-T` cables.

If we try to use the *Full-Duplex method*, we can see that we cannot transmit data because **pins 3 & 6 are not set up to receive data on a switch** *(and also the receiver pins are incorrectly set up)*.



The cables cannot send / receive data this way for two switches

To fix this we **connect the pins to their opposite counterparts** on the other side.



The same would apply if we connected a router to a PC.

Pins 1 & 2 on the left will connect to pins 3 & 6 on the right, pins 3 & 6 will connect to 1 & 2

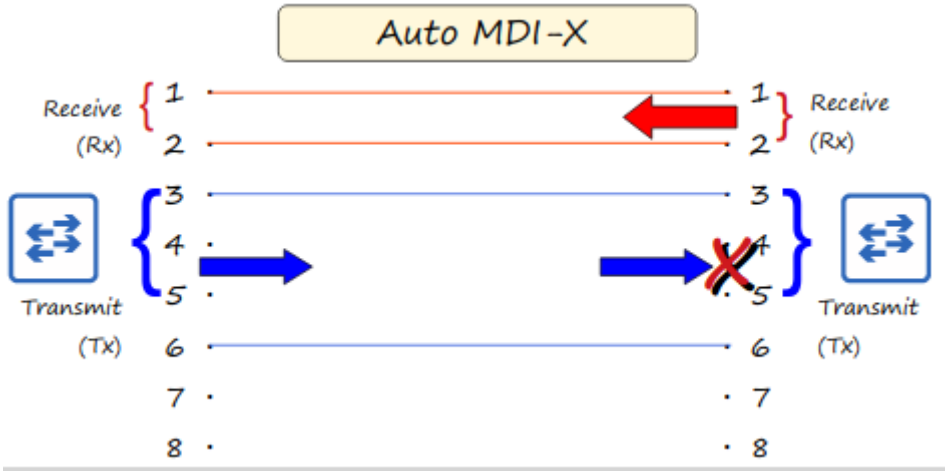
The wires are **crossed over each other** - hence the name Crossover cable. **The transmit pins on one side is connected to the receive pins on the other side**.

Study the table below to grasp the different device types and the different pins the cables use.

Device Type	Transmit (Tx) Pins	Receive (Rx) Pins
Router	1 and 2	3 and 6
Firewall	1 and 2	3 and 6
PC	1 and 2	3 and 6
Switch	3 and 6	1 and 2

Auto MDI-X

This **automatically detects which pin the transmitting data is coming from**, *and then adjust to their pins to receive & transmit the data*.



More modern cables have this but is still good practice to know the straight-through cables and crossover cables.

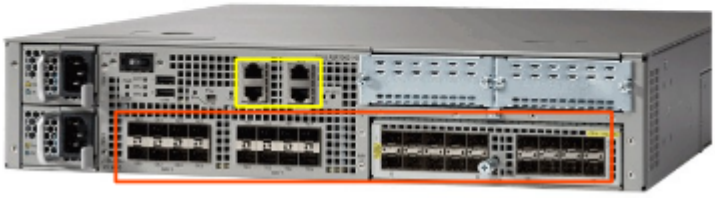
Take note that if an Auto MDI-X is connected to an old network node then the auto detect function will not work.

`1000BASE-T` or `10GBASE-T` cables

Now we will cover the `1000BASE-T` or `10GBASE-T` cables; they have two main differences - they use all **8 wires** and they are **bidirectional (each pair can send & receive data)**.

This is the reason why they operate at much higher speeds.

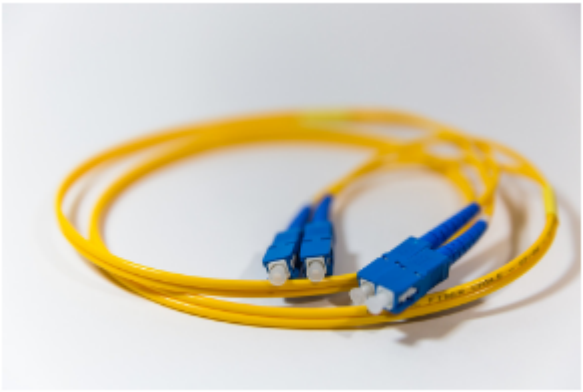
Fibre-Optic Connections



Fibre-Optic ports are highlighted in red, UTP ports are in yellow

UTP cables can only stretch as far as **100 meters** whereas **fibre-optic cables can stretch far longer**. We plug in a **SFP** (**Small Form-Factor Pluggable**) **Transceiver** into the fibre-optic port in order to use the fibre optic cables.

We plug the SFP into the fibre-optic port

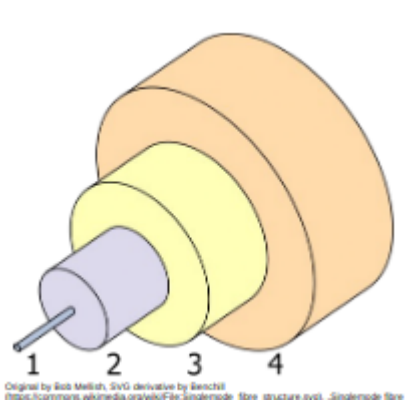


Fibre-optic cables

Instead of sending an electrical signal through copper wiring, they **send light over glass fibres**.

On each end of the cable there are 2 connectors to enable the capability to receive & send data.

Let's take a look at the structure of a fibre optics cable.



1: the fiberglass core itself

2: cladding that reflects light

3: a protective buffer

4: the outer jacket of the cable

single-mode

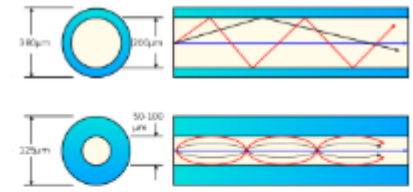
multimode

• The **fibreglass core**: light is transmitted down the core to transmit one device to another
• **Cladding** reflects light
• **Protective buffer**: protects the fibreglass from breaking
• **Outer jacket** protects against the elements

There are **two** main types of fibreglass cables - **single-mode** fibre & **multi-mode** fibre cables.

Multi-Mode Fibre Cables

Here are two examples of a multi-mode fibre cables.



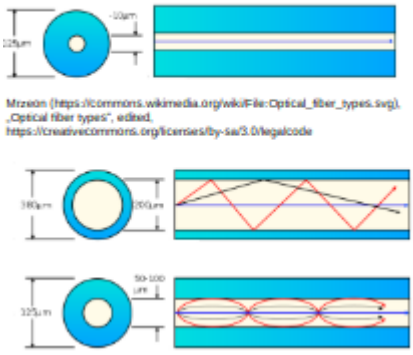
- Core diameter is wider than single-mode fiber.
- Allows multiple angles (modes) of light waves to enter the fiberglass core.
- Allows longer cables than UTP, but shorter cables than single-mode fiber.
- Cheaper than single-mode fiber (due to cheaper LED-based SFP tranmitters).

Study the bullet points

The centre represents the fibreglass core and the blue represents the cladding that reflects the light inside the cable.
Notice the **black & red lines**; this represents the **light-waves travelling down the fibreglass core**, reflecting off the cladding at different angles.

Single-Mode Fibre Cables

Here is an example of a single mode fibre cable compared against two multi-mode fibre cables.



- Core diameter is narrower than multimode fiber.
- Light enters at a single angle (mode) from a laser-based transmitter.
- Allows longer cables than both UTP and multimode fiber.
- More expensive than multimode fiber (due to more expensive laser-based SFP transmitters)

The centre represents the fibreglass core and the blue represents the cladding that reflect the light inside the cable.

You can see the core of a **single-mode fibre cable is much smaller than a multi-mode fibre cable**.

Because the **light enters at a single angle** *(known as a mode)* from a laser transmitter, the light travels in a straight line down the core of the cable.

Fibre-Optic cable Standards

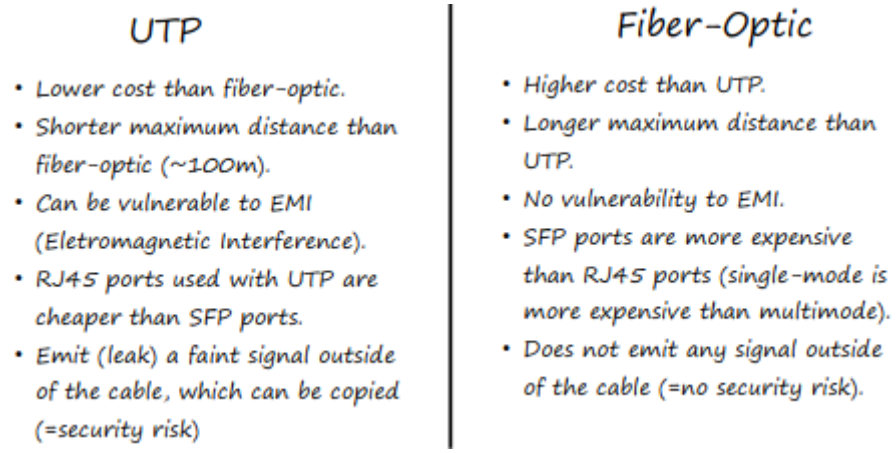
Here is a table of the fibre-optic cable standards. Understand each column in the table.

Informal Name	IEEE Standard	Speed	Cable Type	Maximum Length
1000BASE-LX	802.3z	1 Gbps	Multimode or Single-Mode	550 m (MM) 5 km (SM)
10GBASE-SR	802.3ae	10 Gbps	Multimode	400 m
10GBASE-LR	802.3ae	10 Gbps	Single-Mode	10 km
10GBASE-ER	802.3ae	10 Gbps	Single-Mode	30 km

This is just a sample of the standards, there are many more.

UTP vs Fibre-Optic

We can compare the difference between UTP cables and fibre-optic cables



Because UTP leaks a faint signal, this can be breached to copy data from the network.

REMEMBER !!

• Ports are **also known as interfaces**
• Speed is measured in **bits per second (Bps, Kbs, Mbs, Gbs, etc)**
• Data is sent one **bit at a time, in binary digits** - 8 bits amounting to 1 byte to create a 0 or 1.
• **UTP cables are used in Ethernet standards**. They are the standard for wired connections to switches.
• Full-Duplex transmission allows **network nodes to send and receive data at the same time**
• **Routers, Clients and Firewalls all have the same connection & transmission pins**. Transmit from pins 1 & 2, receive from pins 3 & 6. **A switch is opposite**. They transmit from pins 3 & 6 and receive from pins 1 & 2.
• *Straight-through* cable are pins that connect to the **same pin number**.
• *Crossover cables* **do not connect the pins to the same number** but rather their opposites. The transmission on one side will connect to the receiver on the other side
• **Auto MDI-X** will detect which pin the data is coming from then adjusts its pin accordingly to receive and send the data.
• **Fibre-Optic** cables have a longer distance than UTP cables and are protected against **EMI**.
• UTP **does not** support for **distances over 100m**.
• SFP ports for the fibre-optic cables **are more expensive** than `RJ45` ports