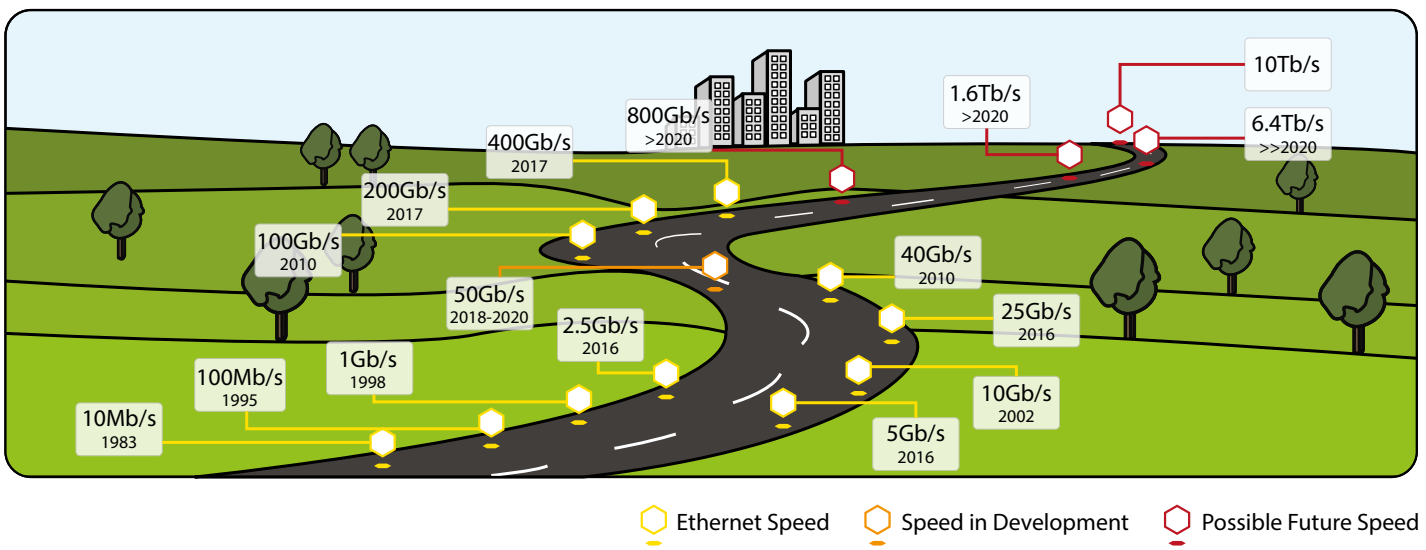
What is a 10G Fiber Network?

Ethernet is a computing network technology that has been in existence nearly since the beginning of network computing. It first came out of Xerox in 1980 and had a transmission speed of 10 Megabits per second (10Mb/s). Subsequent evolutions of Ethernet were released, always in 10 fold increments and, by design, were always backwards compatible. Through the years, the speeds went from 10Mb/s to 100Mb/s to 1000Mb/s or 1 Gigabit per second (1Gb/s) and then to 10Gb/s. After 10Gb/s, the "Ten-fold" increase in speed was abandoned and the next speed was 40 Gb/s. The latest generation of data center networks are now being designed to 400Gb/s and there are already plans for speeds of up to 1.6Tb/s.



In this Explainer, we will look at the technology around Ethernet at 10Gb/s or 10 Gigabit Ethernet (10GbE) running over a fiber optic link in a Local Area Network (LAN) or Data Center (DC) environment.

10GbE networks for the Datacom environment were first introduced to the market in 2002, with several options for achieving 10GbE transmission – 10GBASE-SR, 10GBASE-LR, 10GBASE-ER and 10GBASE-LX4 for LAN and DC applications and 10GBASE-SW, 10GBASE-LW & 10GBASE EW for Wide Area Network (WAN) applications. All of these options had different characteristics, used different types of lasers and different types of optical fibers and achieved different transmission lengths. Importantly, the different options had very different cost points.

Over the next few years, the options for the LAN and DC applications reduced to three main protocols – SR (Short Wavelength, Short Reach), LR (Long Wavelength, Long Reach) and ER (Extra Long Wavelength, Extended Reach). The main characteristics of each can be seen below.

Protocol	Name	Transceiver	Media	Wavelength	Range
10GBASE-SR	Short Wavelength, Short Reach	XENPAK, X2, XFP, SFP+	MM (Multimode) OM3 MM (Multimode) OM4	850nm	300m 400m
10GBASE-LR	Long Wavelength, Long Reach	XENPAK, X2, XFP, SFP+	SM (Singlemode) OS2	1310nm	10km
10GBASE-ER	Extra Long Wavelength, Extended Reach	XENPAK, X2, XFP, SFP+	SM (Singlemode) OS2	1550nm	40km

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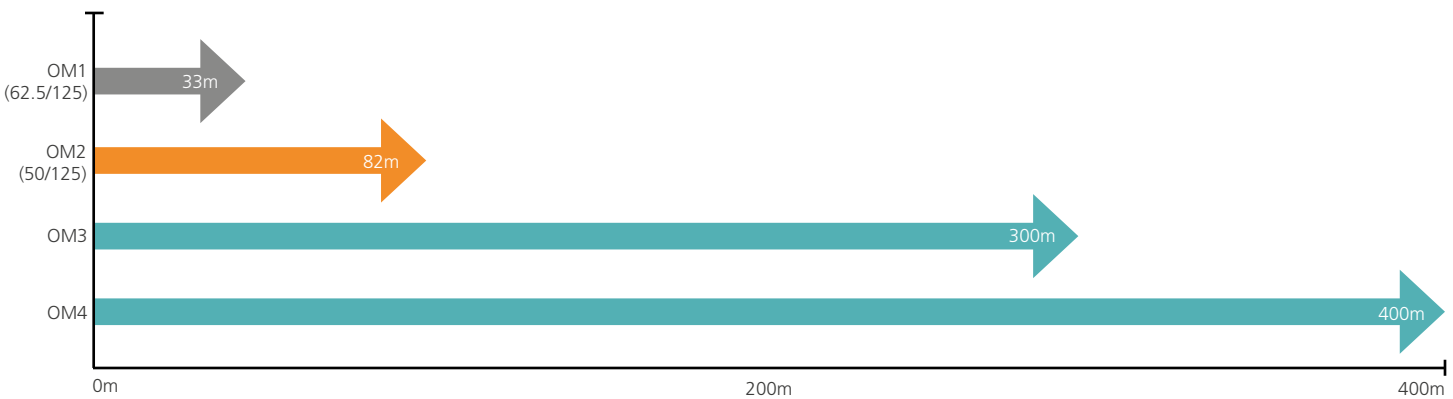
10GbE network switches are manufactured with ports which then have transceivers (Transmit/Receive) plugged into them. The main function of the transceiver is to translate the 10GbE electrical signals in the switch into optical signals which can then be sent down the fiber and vice versa. In the early days of 10GbE there were a variety of different transceivers but, quite soon after, the Small Form-factor Pluggable (SFP+) transceiver based on the LC Duplex connector became the de facto standard. It had a very small footprint and lower power consumption than the previous form factor transceivers and allowed up to 48 ports in a 1 Rack Unit (1RU) network switch.

The advent of 10GbE was a time of great change for fiber optic networks in the LAN and DC. These new 10GBASE-SR transceivers deployed VCSEL (Vertical Cavity Surface Emitting Lasers) lasers which were cheaper than single mode lasers but more powerful than previously deployed multimode Light Emitting Diode (LED) emitters. These VCSEL lasers had a very focused light spot (approx. 30µm diameter) and required new laser optimized multimode fibers. Traditional OM1 (62.5/125) and OM2 (50/125) cabled optical fibers (fibers) could be used but their ranges were very limited (33m & 82m respectively) due to their limited bandwidth capacity. The new enhanced bandwidth fibers are standardized by ISO/IEC 11801-1 as OM3 and OM4 with distance capability of 300m and 400m respectively. Both OM3 and OM4 fiber cables were commonly supplied with an Aqua color jacket in order to differentiate them from the traditional orange or grey jacketed OM1 and OM2 fiber cables.

10GBase-SR Distances in Multimode Networks



In the specification document for the 10GBASE-SR, a maximum channel insertion loss was defined as 2.6 dB when using OM3 over 300m and 2.9 dB when using OM4 over 400m. The channel insertion loss referred to the total optical signal loss of the fiber cabling from the transceiver on one end of the channel to the transceiver on the other end of the channel. These two parameters are very closely linked such that as the length of the channel decreases the allowable loss increases by a value greater than the reduced optical attenuation due to the shorter length of fiber. This is due to incremental penalty loss margins added as the length reaches maximum distance to accommodate the effects of signal distortion. By utilising OM4 fiber, the maximum link can be extended out to 400m and beyond with higher specification transceivers.

In summary, today's 10GbE networks are built with a maximum reach of 300m using OM3 fiber and 400m using OM4 fiber. They utilise LC Duplex connectors and have a maximum channel insertion loss of 2.6 dB for OM3 and 2.9 dB for OM4. 10GbE network switches now have port counts up to 48X 10GbE ports for device connectivity and up to 6X 40GbE for network uplinks. All 10GbE ports in modern optical networks are populated with SFP+ transceivers.