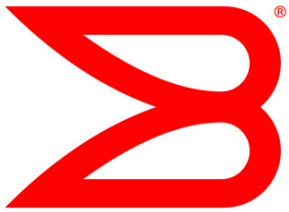

DATA CENTER

The Evolution of Ethernet Nomenclature

Terms that define Ethernet ports, such as 10GBASE-SR, often have two meanings—one from the standard and one from the industry. This paper explains the industry nomenclature of the most common types of Ethernet ports.

BROCADE

CONTENTS

ETHERNET NOMENCLATURE

Ethernet is the most ubiquitous networking technology. It has grown from its roots in enterprise networks, and now addresses other markets such as data centers, storage, metro, wide area, and carrier networks. The IEEE 802.3 Ethernet Working Group develops Ethernet's physical layer standards and distinguishes each of these links by its *port type* or *port name*. The standards do not spell out the meaning of most of the letters, so informal terms have been adopted by the industry. Although they work for many link types, they fail on several specific link types. This paper discusses the evolution of the nomenclature from an industry perspective as well as from the perspective of the standards committees that defined the nomenclature.

The informal terms used in the Ethernet industry are often not based on the standards that defined the terminology. Terms such as Short Reach (SR) for 10GBASE-SR, Long Reach (LR) for 10GBASE-LR, and Extended Reach (ER) for 10GBASE-ER became prevalent with the introduction of 10 Gigabit per second (Gbps) links. This terminology was probably adopted from telecom nomenclature, where the same acronyms are used. The informal terms are, however, very useful because they are easy to remember and usually accurate, for example, SR links are used for relatively short reach applications.

The different port names for each link type are defined in the Ethernet standard. The standard defines three fields:

	<data rate>	<modulation type>	<additional distinction>
Example:	100G	BASE	-LR4)

- The <data rate> field of the port name defines the data rate expressed in Megabits per second (Mbps) if only a number or Gigabits per second (Gbps) if suffixed by the letter "G."
- The <modulation type> field of the port name defines how the data is transmitted on the medium. For all port names considered by the paper, the 'modulation type' field is 'BASE' for Baseband.
- The 'additional distinction' field of the port name identifies additional characteristics such as reach, medium, and type of encoding. Other than three examples provided in subclause 1.2.3 ('T' for twisted pair, 'B' for bidirectional optics, and 'X' for a block PCS coding), there is no further guidance provided in respect to the meaning of the individual letters and numbers used in the 'additional distinction' field. The lack of direct correlation of letters to meaning has led to confusion when the individual letters have been interpreted.

This paper shows how the letters in the nomenclature can be associated with specific meanings. Underlined letters denote the letter of a word that is used in the nomenclature. For example, the T in 100BASE-T stands for Twisted pair. The Ethernet standard does not explicitly make this association. Figure 1 shows an interpretation of the port name format defined in subclause 1.2.3 of the Ethernet standard. An example may help clarify how the Figure 1 could be used. 100BASE-LX represents a 100 Mbps port with BASEb and modulation that has a Long wavelength laser that uses eXternal sourced coding.

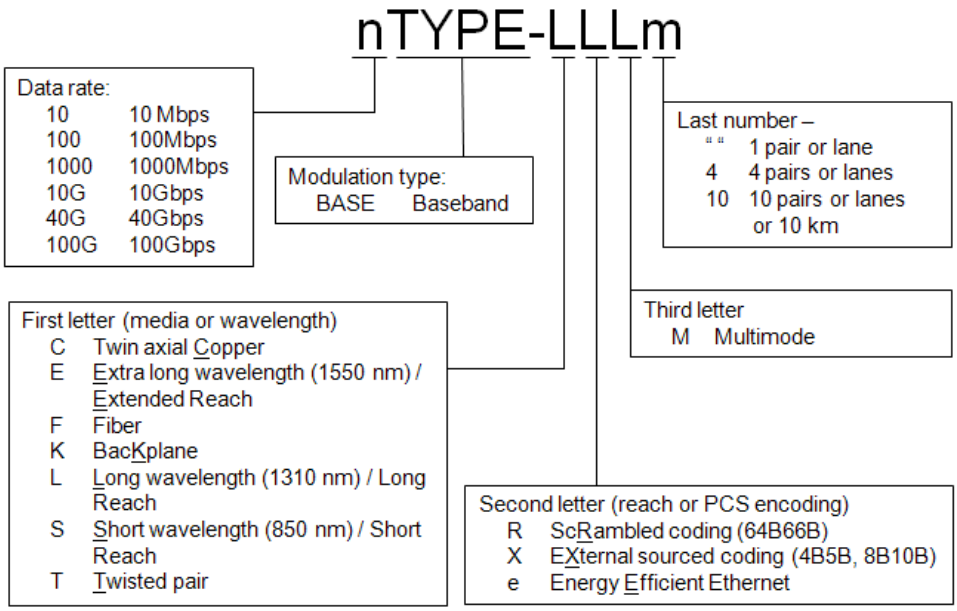

Figure 1. Ethernet link nomenclature

Ethernet and its nomenclature evolved with every jump in speed and new project. This paper follows a chronological order that corresponds to each jump in speed. While almost all link types that are being used today in the enterprise are covered, this chart and paper were kept simple by excluding several application spaces. Application spaces not included in this paper include wireless, Passive Optical Networks (PON) and Wide Area Networks (WAN); and, obsolete link types have been excluded for simplicity.

ETHERNET (10 MBPS)

The first standard version of Ethernet used coaxial cable and operated at 10 Mbps. The main type of 10 Mbps Ethernet deployed today is 10BASE-T. 10BASE-T operates over two Twisted-pairs of telephone wire (26 to 22 AWG), or better, terminated with RJ-45 connectors. The two twisted-pairs are used as two simplex links: one twisted-pair to transmit in one direction and one twisted-pair to transmit in the other direction. While many switches support 10BASE-T for backward compatibility, most ports auto-negotiate to the higher speeds of either 100BASE-T or 1000BASE-T.

Since the majority of Ethernet ports sold have an RJ-45 connector and support 10BASE-T, 100BASE-T and 1000BASE-T, these ports are often referred to as 10/100/1000 or 10/100/1000BASE-T ports. As shown in Figure 2, the RJ-45 is found on almost every personal computer and Ethernet switch.

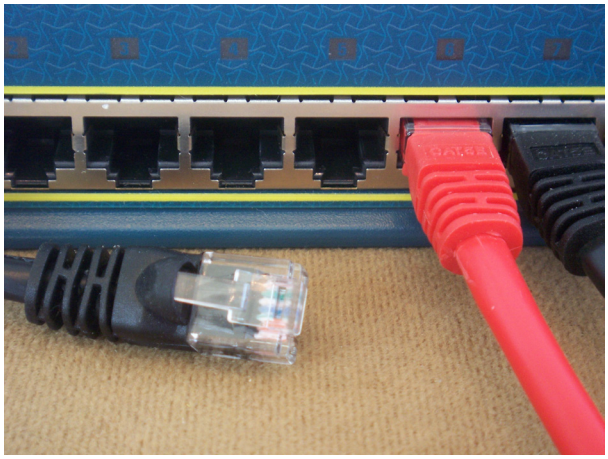

Figure 2. The ubiquitous RJ-45

The newest 10 Mbps Ethernet technology is 10BASE-Te. The "e" in 10BASE-Te stands for energy efficiency Ethernet. Energy Efficient Ethernet (EEE) defines new ways of reducing the power consumed by links to save energy. To reduce the power consumption of 10BASE-T, EEE lowers the voltage swings of the 10BASE-T signals from about 2.5 volts to about 1.75 volts so that less power is consumed across the twisted pairs. The main way that EEE saves power though is by putting the link to sleep for negotiated periods of time. 10BASE-Te should start appearing on port nomenclature in 2011.

Table 1. Nomenclature for Ethernet (10 Mbps)

Nomenclature	Distinctions
10BASE-T	Electrical link over two Twisted-pairs of wire (Category 3 or better). Supports up to at least 100 m.
10BASE-Te	Electrical link over two Twisted-pairs of wire (Category 5 or better), with a more energy efficient lower transmit voltage. Supports up to at least 100 m.

FAST ETHERNET (100 MBPS)

Fast Ethernet operates at 100 Mbps and has the largest installed base of links according to Dell'Oro[1]. The main types of Fast Ethernet links are 100BASE-TX, 100BASE-FX and 100BASE-LX. 100BASE-X links use 4B/5B coding to encode and decode the data and is specified eXternal to the IEEE 802.3 standard by referencing to the FDDI standard. 100BASE-TX, which is almost universally known by the vernacular of 100BASE-T, operates over two Twisted-pairs of Category 5 cabling, or better (Category 6/6A) and is terminated with RJ-45 connectors. 100BASE-T increases the speed of 10BASE-T by an order of magnitude and uses the same two twisted-pairs of wires as 10BASE-T.

100BASE-FX was the first 100Mbps Fiber link to be defined and used "F" as the "additional distinction" field of the port name. 100BASE-FX links use two 62.5µm "FDDI grade" (160/500 MHz·km modal bandwidth) multimode fibers to support up to at least 2 kilometers. (See Appendix A for a description of fiber type and electrical cables.) Since 100BASE-LX10 uses Long wavelength lasers at 1310 nm, eXternal coding and supports at least 10 kilometers over single-mode fibers, "LX10" was used as the "additional distinction" field of the port name. In both cases the fibers use two simplex links. Over 90% of Fast Ethernet links are 100BASE-T links.

1. Ethernet Switch Report Five Year Forecast 2010-2014, www.delloro.com

Table 2. Nomenclature for Fast Ethernet (100 Mbps)

Nomenclature	Distinctions
100BASE-TX	Electrical link over two Twisted-pairs of wires (Category 5 or better), with eXternal sourced coding. Supports up to at least 100 m.
100BASE-FX	Optical link that uses short wavelength (850 nm) lasers over two FDDI grade multimode optical Fibers, with eXternal sourced coding. Supports up to at least 2 km.
100BASE-LX10	Optical link that uses Long wavelength (1310 nm) lasers over two single-mode optical fibers, with eXternal sourced coding. Supports up to at least 10 km.

100BASE-FX links support up to at least 2 kilometers over multimode fiber and are often used in applications with high levels of ElectroMagnetic Interference (EMI,) since optical fiber is highly immune to this type of interference. For long-reach applications outside the data center, 100BASE-LX supports up to 10 kilometers over single-mode fiber for campus environments. Short reach links are more common and usually cost considerably less than long reach links.

GIGABIT ETHERNET

Gigabit Ethernet (GbE) ports have been the workhorse of the data center for several years now and began shipping more ports than Fast Ethernet for the first time in 2010, according to Dell'Oro. Over 90% of GbE links are 1000BASE-T links that operate over four Twisted-pairs of Category 5 cabling, or better, terminated with RJ-45 connectors. The four twisted-pairs are used as four duplex links where all four twisted-pairs are used to transmit in both directions at the same time while 10 and 100 Mbps Ethernet use only two simplex pairs.

All other GbE links are in the 1000BASE-X family and use eXternal 8B/10B coding to encode and decode the data. The eXternal source for the coding in the IEEE 802.3 standard is the Fiber Channel standard. For shorter distances up to 25 meters where structured cabling is not required, 1000BASE-CX uses copper cables and eXternal source coding. 1000BASE-CX uses a jumper cable assembly that contains two pairs of twin axial cable terminated with D-sub connectors.

Table 3. Nomenclature for Gigabit Ethernet (1 Gbps)

Nomenclature	Distinctions
1000BASE-T	Electrical links over four Twisted pairs of wires (Category 5 or better). Supports up to at least100 m.
1000BASE-CX	Electrical link that uses two pairs of Copper wires in a jumper cable assembly with eXternal sourced coding. Supports up to at least 25 m.
1000BASE-SX	Optical link that use Short wavelength (850nm) lasers over two multimode optical fibers with eXternal sourced coding. Supports at least 550 m on OM2 fiber.
1000BASE-LX	Optical link that uses Long wavelength (1310nm) lasers with eXternal sourced coding. Supports at least 5 km on single-mode fiber and up to at least 550 m on OM1 and OM2 fiber with 500 MHz-km modal bandwidth at 1300 nm.
1000BASE-KX	BacKplane link with eXternal sourced coding that uses two pairs of traces. Supports up to at least 1 m of backplane traces.

The fiber optic solutions for GbE consist of 1000BASE-SX and 1000BASE-LX. The "S" in "SX" stands for Short wavelength and the lasers are now based on Vertical Cavity Surface Emitting Lasers (VCSELs), which emit light in the 850 nm range. VCSELs are coupled with multimode fiber to provide cost-effective solutions in the data center to 550 meters on OM2 fiber. The "L" in "LX" stands for Long wavelength and corresponds to lasers that emit in the 1310 nm wavelength of light. 1000BASE-LX was designed to work with single-mode fiber up to 5 kilometers, but the optical modules can also be coupled to multimode fiber for distances up to 550 meters.

> While the standard for 1000BASE-LX only specifies single-mode links up to 5 km, most module vendors have exceeded the standard and support distances to 10 km or more. These 10 km modules are often known as 1000BASE-LH (for Long Haul) or 1000BASE-LX10 (for 10 km).

One of the latest types of GbE links is 1000BASE-KX. 1000BASE-KX transmits GbE over backplanes of Ethernet equipment. The 1000BASE-KX ports are not external ports and are internal interfaces to blade servers and switches. 1000BASE-KX was defined as part of 802.3ap Backplane project along with 10 Gbps Backplane Ethernet links.

10 Gigabit Ethernet (10 GbE)

The development of 10 Gbps Ethernet (10 GbE) lead to a large number of link types that reflected the growing application space for Ethernet. Nine 10 GbE links are summarized in Table 4, including two copper-based links, two backplane links, and five optical links. Table 4 does not include the three 10GBASE-W links designed for Wide Area Network (WAN) applications, because there have been few deployments of 10GBASE-W links. Several other types of 10 GbE links that were standardized are discussed.

Nearly all the optical, copper, and backplane links for 10 GbE can be broken up into two families: the 10GBASE-X family with four lanes at 3.125 Gbps and the 10GBASE-R family with one lane of 10.3125 Gbps. The 10GBASE-X family uses eXternal sourced 8B/10B coding to transfer the 10 Gbps of data as four lanes of 2.5 Gbps resulting in 3.125 Gbaud operation on each lane. The 10GBASE-X family consists of 10GBASE-CX4 and 10GBASE-KX4. The 10GBASE-R family uses scRambled 64B/66B coding resulting in 10.3125 Gbaud operation. The 10GBASE-R family consists of 10GBASE-KR, 10GBASE-SR, 10GBASE-LR, and 10GBASE-ER.

Table 4. Nomenclature for 10 Gigabit Ethernet (10 Gbps)

Nomenclature	Distinctions
10GBASE-T	Electrical links over four Twisted pairs of wires (Category 6 or better) with bi-directional signaling. Supports up to at least 100 m.
10GBASE-CX4	Electrical link that use 4 pairs of Copper wires with bi-directional signaling in a jumper cable assembly with eXternal sourced coding. Supports up to at least 15 m.
10GBASE-SR	Optical link that uses Short wavelength (850nm) lasers over two multimode optical fibers with scRambled encoding. Supports up to at least 300 m on OM3 fiber.
10GBASE-LR	Optical link that uses Long wavelength lasers (1310nm) and two single-mode optical fibers with scRambled encoding. Supports up at least to 10 km.
10GBASE-ER	Optical links that use Extra long (1550nm) wavelength lasers and two single-mode optical fibers with scRambled encoding. Supports up to at least 40 km.
10GBASE-LRM	Optical link that use Long wavelength (1310nm) lasers with scRambled encoding over Multimode fiber. Supports up to at least 220 m on FDDI grade fiber.

Nomenclature	Distinctions
10GBASE-LX4	Optical link that uses Long wavelength (4 wavelengths in 1310 nm range) lasers with eXternal sourced coding and wavelength division multiplexing into one multimode fiber. Supports up to at least 300 m of FDDI grade fiber.
10GBASE-KX4	BacKplane link with eXternal sourced coding that uses 4 bi-directional traces. Supports up to at least 1 m.
10GBASE-KR	BacKplane link with scRambled encoding that uses 1 pair of traces. Supports up to at least 1 m.

The one 10 GbE link that is not a member of these families is 10GBASE-T. 10GBASE-T operates over four Twisted-pairs of Category 6 or Category 6A structured cabling, or better, terminated with RJ-45 connectors. The four twisted-pairs are used as four duplex links similar to 1000BASE-T.

The industry has widely adopted the terms short reach, long reach and extended reach to match 10GBASE-SR, 10GBASE-LR, and 10GBASE-ER respectively. From an IEEE standards perspective, the "R" stands for 64B/66B scRambled data while the "S" represents the 850 nm Short wavelength, the "L" stands for the 1310 nm Long wavelength, and the "E" stands for the 1550 nm Extra long wavelength. At 10 Gbps, these three wavelengths of lasers do correlate with distance, where 850 nm (SR) VCSELs are used with multimode fiber for up to 300 meters while 1310 nm (LR) and 1550 nm (ER) use single-mode fiber over longer distances. The short reach, long reach, and extended reach terminology was originally used in SONET, but the Ethernet industry adopted it because it is so convenient and easy to remember.

Non-Standard 10 GbE Links

Some vendors sell 10GBASE-ZR modules that usually support 80 kilometer distances. IEEE has not defined a standard for 10GBASE-ZR PMD, so supported distances and implementations vary from vendor to vendor. 10GBASE-USR (Ultra-Short Reach) modules are not standards based and usually support distances of 100 or 150 meters. SFP+ Twinax cables have not been standardized by the IEEE and do not have standard nomenclature.

Two optical links were developed to support the installed base of FDDI grade (62.5 µm 160/500 MHz·km) multimode fiber, initially 10GBASE-LX4 and then 10GBASE-LRM. The 10GBASE-LX4 symbolizes the 4 lanes of Long wavelength lasers that use eXternal source 8B/10B coding. 10GBASE-LX4 also uses a Wavelength Division Multiplexer (WDM) so that only two single-mode fibers are needed for up to 10 kilometers or two multimode fibers for distances up to 300 meters. 10GBASE-LRM uses Long wavelength lasers with 64B/66B scRambled coding over Multimode fiber. Operating at 10.3125 Gbps, this link type is designed to run over FDDI grade fiber, for up to 220 meters. The 10GBASE-LRM modules use electronic dispersion compensation (EDC) circuitry to recover signals that are distorted by the FDDI grade fiber. These two optical link types enable 10 GbE links to work over the installed base of optical fibers.

40 Gigabit Ethernet (40 GbE)

40 GbE supports five port types with link distances ranging from 1 meter to 10 kilometers. All 40 GbE links use 40GBASE-R encoding over 4 lanes with 64B/66B scRambled encoding.

The two 40 GbE electrical links are 40GBASE-KR4 and 40GBASE-CR4. 40GBASE-KR4 is designed for bacKplane applications with scRambled encoding over 4 pairs of traces in each direction to deliver high bandwidth up to at least 1 meter over backplanes. 40GBASE-CX4 supports up to at least 7 meters over 4 Copper wires with scRambled encoding in each direction in a jumper cable assembly. 40GBASE-CX4 is for top-of-rack or adjacent rack connections.

The three optical links defined for 40 GbE are 40GBASE-SR4, 40GBASE-LR4, and 40GBASE-FR. The nomenclature for 40GBASE-SR4 can be interpreted in two ways, SR = Short Reach with 4 lanes or Short wavelength lasers with scRambled encoding over 4 lanes in each direction. The 4 lanes operate at 10.3125 Gbps over 100 meters on Optical Multimode 3 (OM3) fiber or 150 meters over engineered links on Optical Multimode 4 (OM4) fiber. 40GBASE-LR4 nomenclature can be interpreted as LR = Long Reach over 4 lanes or4 lanes of Long wavelength lasers with scRambled encoding over single-mode fiber for up to 10 kilometers. The 4 colored lasers are multiplexed with a WDM so that only two fibers, one in each direction, are needed on the long link. 40GBASE-FR stands for Fiber with scRambled encoding. 40GBASE-FR uses an electrical gearbox to mux the 4 electrical lanes of 10.3125 Gbps into one lane of 41.25 Gbps. This electrical lane modulates a single 1550 nm laser at 41.25 Gbps, so no number follows the 40GBASE-FR nomenclature since the number “1” is implied. 40GBASE-FR is mainly used to interface to WAN equipment.

Table 5. Nomenclature for 40 GbE

Nomenclature	Distinctions
40GBASE-KR4	BacKplane link with scRambled encoding over 4 pairs of traces in each direction. Supports up to at least 1 m.
40GBASE-CR4	Electrical link that uses Copper wires in a jumper cable assembly with scRambled encoding over 4 pairs of wires in each direction. Supports up to at least 7 m.
40GBASE-SR4	Optical link that uses Short wavelength (850nm) lasers with scRambled encoding over 4 multimode optical fibers in each direction. Supports Short Reach applications up to at least 100 m on OM3 fiber or at least 150 m over engineered links on Optical Multimode 4 (OM4) fiber.
40GBASE-LR4	Optical link that uses 4 Long wavelength (near 1310 nm) lasers with scRambled encoding over two single-mode optical fibers. Supports Long Reach applications up to at least 10 km.
40GBASE-FR	Optical link that uses 1 extra long wavelength (near 150 nm) lasers over two single-mode optical Fibers with scRambled encoding. Supports applications up to at least 2 km.

100 Gigabit Ethernet (100 GbE)

Similar to 40 GbE, 100 GbE uses electrical lanes of 10 Gbps with scRambled encoding to create 100 Gbps links. 100GBASE-CR10 supports links up to 7 meters over 10 pairs of Copper wires in each direction in a jumper cable assembly. 100GBASE-SR10 is an optical link that uses Short wavelength lasers with 10 parallel fibers in each direction and supports Short Reach link distances up to 100 meters on OM3 fiber or 150 meters over OM4 fiber on engineered links.

The Long Reach applications over single-mode fibers took an interesting turn at 100 Gbps. Since single-mode fibers extend over long distances and are expensive to install, 100GBASE-LR and 100GBASE-ER modules use a gearbox to convert the 10 x 10 Gbps electrical lanes into 4 lanes of 25 Gbps so that fewer lasers are multiplexed onto a fiber.

Both 100GBASE-LR4 and 100GBASE-ER4 are optical links that use 4 lanes of long wavelength lasers (near 1310 nm) and Wavelength Division Multiplexer (WDM) so that only one single-mode fiber is required in each direction. 100GBASE-ER4 uses the same 1310 nm lasers as 100GBASE-LR4 but also uses optical amplification to Extend the reach of the link to go up to 40 km. 100GBASE-LR4 supports Long Reach links of up to at least 10 kilometers on single-mode fiber. 100GBASE-ER4 supports Extended Reach links of up to at least 40 kilometers on single-mode fiber. While the "E" in 10GBASE-ER stood for the Extra long wavelength laser of 1550 nm, the "E" in 100GBASE-ER stands for the Extended Reach of the link. The IEEE P802.3ba Task Force agreed to use industry terminology for the nomenclature of these single-mode links.

A new standard for 100 GbE is known as LR10 and is being defined for low cost. LR10 is also known as the 10x10-2km link from the 10X10 MSA. The 10x10-2km link doesn't use the 10:4 gearbox used in 100GBASE-LR4 and uses 10 lasers in the 1550 nm range to go 2 kilometers. The SFF Committee will standardize this link.

Table 6. Nomenclature for 100 Gigabit Ethernet (100 GbE)

Nomenclature	Distinctions
100GBASE-CR10	Electrical link that uses 10 pairs of Copper wires in each direction with scRambled encoding. Supports up to at least 7 m.
100GBASE-SR10	Optical link that uses Short wavelength (850 nm) lasers with scRambled encoding over 10 pairs of multimode optical fibers in each direction. Supports Short Reach applications up to at least 100 m on OM3 fiber or at least 150 m over engineered links on Optical Multimode 4 (OM4) fiber.
LR10	Optical link that uses 10 Long wavelength (near 1550 nm) lasers with scRambled encoding over two single-mode optical fibers. Supports Long Reach applications up to at least 2 km. This is based on the 10X10 MSA and not an IEEE standard.
100GBASE-LR4	Optical link that uses 4 Long wavelength (near 1310 nm) lasers with scRambled encoding over two single-mode optical fibers. Supports Long Reach applications up to at least 10 km.
100GBASE-ER4	Optical link that uses 4 long wavelength (near 1310 nm) lasers with scRambled encoding and two single-mode optical fibers. Supports Extended Reach applications of up to at least 40 km.

CONCLUSION

Ethernet has expanded into new applications by addressing new reaches, new media, and new speeds on links. While original Ethernet supported 500-meter links on coaxial cable, modern 100 GbE links support distances of up to 40 kilometers. Figure 3 summarizes the link speeds and supported distances for the Ethernet nomenclature described in this paper. From linking data centers to linking cards within a blade server, Ethernet has become the dominant data communication channel in the world.

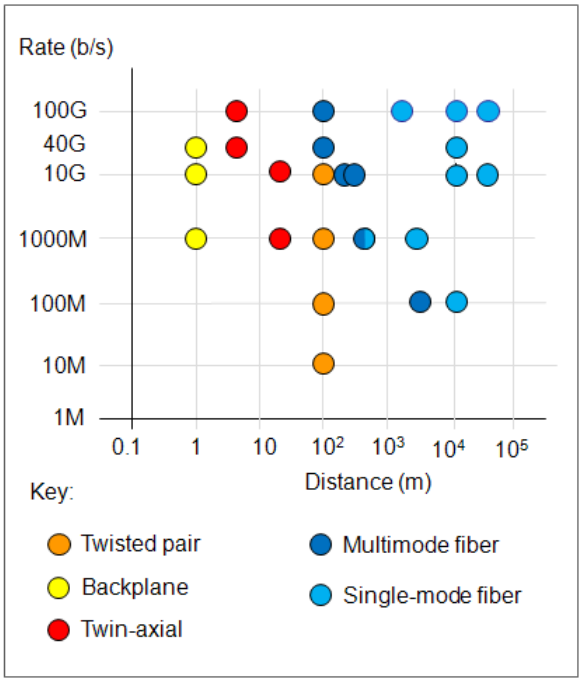

Figure 3. Link speed and distance (graph created by David Law of HP and presented at the IEEE/ITU Workshop on Next Generation Networks, May 2010)

The nomenclature to support this wide variety of links has also grown and evolved over the years. From basic Twisted pair technology of BASE-T, nomenclature mirrored the evolution of the copper physical layer to include other Copper cabling and backplane connections. As the encoding moved from eXternally referenced 4B/5B and 8B/10B to internally defined scRambled 64B/66B, the nomenclature changed from BASE-X to BASE-R. The evolution of laser and fiber optic technologies also brought changes in the optical nomenclature from F to SR to LR and ER. The industry has also had their say with terms such as short reach, long reach, and extended reach in common use. This paper sheds some light on the nomenclature of Ethernet links that are used in most enterprises today.

APPENDIX A: ETHERNET MEDIA

External Ethernet links operate over two general types of media: copper wires and optical fibers. The vast majority of copper links use Category (CAT) cabling but Twin-Axial (Twinax) cables are also deployed. For optical fiber; the two main branches are multimode and single-mode fiber. Each of these media has gone through multiple generations as shown in the following tables.

Table 7. Category cables

Cable Type	Description	Standards
Category 1 (CAT 1)	Not used in Ethernet. Voice-grade copper wire used for telephone communications, ISDN and doorbells.	N/A
Category 2 (CAT 2)	Not used for Ethernet. Copper cabling used in ARCnet and 4 Mbps Token Ring.	N/A
Category 3 (CAT 3)	4 wire copper cabling designed for speeds up to 16 MHz and used for 10BASE-T.	TIA/EIA-568-B
Category 4 (CAT 4)	Not used in Ethernet. Copper cabling designed for speeds up to 20 MHz and used in 16 Mbps Token Ring	N/A
Category 5 (CAT 5)	8 wire copper cabling designed for speeds up to 100 MHz and used in Fast Ethernet.	TIA/EIA-568-A-1995 ISO/IEC 11801:1995 Class D structured cabling.
Category 5e (CAT 5e)	8 wire copper cabling designed for speeds up to 100 MHz.	TIA/EIA-568-B
Category 6 (CAT 6)	8 wire copper cabling designed for speeds up to 250 MHz.	TIA/EIA-568-A-1995, tested to TIA/EIA TSB-155 ISO/IEC 11801:Class E tested to ISO/IEC TR-24750)
Augmented Category 6a (CAT 6a)	8 wire copper cabling designed for speeds up to 500 MHz and designed to support 10GBASE-T up to at least 100 m.	TIA/EIA-568-B.2-10 Category 6A (ISO/IEC 11801:1995 Class EA)
Category 7 (CAT 7)	8 wire copper cabling designed for speeds up to 600 MHz and used for 10GBASE-T.	ISO/IEC 11801:2002 Class F
Category 7a (CAT 7a)	Copper cabling designed for speeds up to 1000 MHz and used for 10GBASE-T.	ISO 11801 Amendment 1:2008

All optical fibers are standardized in ISO/IEC 11801.

Table 8. Optical fiber

Category	Core Diameter (um) (All fiber has a 125um cladding)	Bandwidth Length Product at 850nm (MHz*km or GHz*m)	Bandwidth Length Product at 1310nm (MHz*km or GHz*m)
FDDI Grade	62.5	160	500
Optical Multimode 1 (OM1)	62.5	200	500
Optical Multimode 2 (OM2-400)	50	400	500
Optical Multimode 2 (OM2)	50	500	500
Optical Multimode 3 (OM3)	50	1500 / (2000 under “Laser” launch conditions)	500
Optical Multimode 4 (OM4)	50	4700	500
Optical Single-mode 1 (OS1)	9	N/A	Nearly infinite