SEPT 2015

Next Generation Ethernet

White Paper

HellermannTyton

Introduction

Ethernet speeds have been increasing steadily since its formal standardisation as IEEE Std 802.3 in June of 1983 and that trend is set to continue for a while longer at least.

However, gone are the days when it was easy to predict what the next speed increase would be. Of course, back when the world was still in awe of 10 Mb/s, IEEE Std 802.3 was a copper-only protocol and the likes of IPv4 would last forever. Nowadays, the world is a different place and more data is transmitted over fibre-based Ethernet networks than copper ones. In addition various speeds of Ethernet have branched out of the safe environment of the typical office network and are now delivering services over long-haul fibre and fibre to the home (FTTH) networks.

Up until very recently the jump from one Ethernet speed to the next was simply a matter of adding another zero to the number of megabits per second (Mb/s). So 10 Mb/s Ethernet became 100 Mb/s Ethernet which in turn became 1000 Mb/s Ethernet. Figure 1 shows the consistent evolution of Ethernet over twisted pairs up to 10GBASE-T. However, to support this increase in Ethernet speeds numerous ingenious things had to happen; these were the development of a suitable encoding scheme to allow the required data rates to be transmitted and received without error[1] and the definition of a suitable physical layer, which for BASE-T Ethernet technologies is copper.

Over the years the successive increases in Ethernet speeds have given rise to increases in cabling speeds too. The Telecommunications Industry Association (TIA) and the

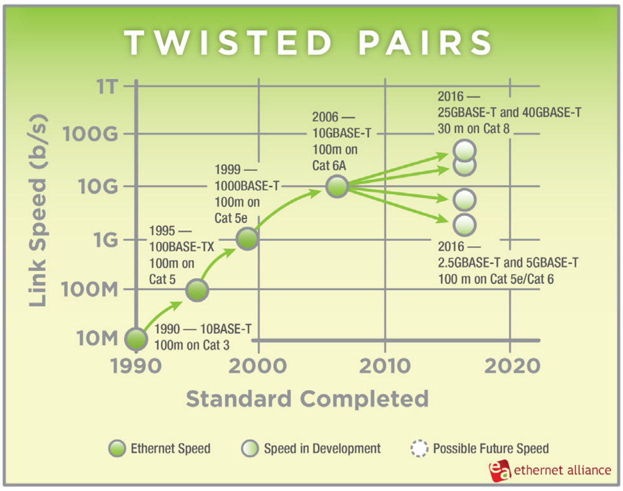

Figure 1 - Evolution of Ethernet

International Standard Organisation (ISO) have worked closely with the Institute of Electrical and Electronic Engineers (IEEE) and the Ethernet Alliance to ensure that the cable performance requirements needed to support the next generation of Ethernet technology can be met.

Cabling performance and supported Ethernet

Whilst most people implementing an Ethernet network are only concerned about the speed of transmission of their data, or the Mb/s they'll achieve, the cabling industry is all about the number of Mega-Hertz (MHz) needed to deliver the data at the required speed. Whilst many do not appreciate the differences between these two units it should be recognised that the Mb/s value is the actual number of bits, 1's or 0's, that are transmitted along the cabling, whereas the MHz value is the maximum frequency, sometimes also referred to as bandwidth, that the physical cabling will support. These two units were, and still are, used interchangeably since 100BASE-T Ethernet was standardised during the mid-1990s which required the performance of a cabling system characterised to 100 MHz. It has also been safe to assume that the more data you want to transmit over the network, or to put it another way the higher the Mb/s, the greater the bandwidth required.

[1] The basis of Ethernet transmission uses something called Carrier Sense Multiple Access with Collision Detection (CSMA/CD) and cyclic redundancy check codes (CRCs) to enable detection and correction of some errors.

Ethernet	IEEE Standard	Cabling Category	Bandwidth (MHz)	Maximum Length (m)	No. of Pairs	Coding Scheme	Publish Year
10BASE-T	802.3?	TIA Category 3 ISO/IEC Class C	16	100	2	PAM-3	1983
100BASE-T	802.3y	TIA C5	100	100	2	PAM-3	1998
1000BASE-T	802.3ab	TIA C5e ISO/IEC Class D	100	100	4	PAM-5	1999
2.5GBASE-T 5GBASE-T	802.3bz				4		
10GBASE-T	802.3an	TIA C6A ISO/IEC Class EA	500	100	4	PAM-16[2]	2006
25GBASE-T	802.3by				4		
40GBASE-T	802.3bq	TIA Category 8 ISO/IEC Category 8	2000	30	4		2016 expected

Table 1 – Data Rate and Encoding Schemes for Ethernet

This has been further substantiated with 10GBASE-T requiring 500 MHz of bandwidth, and higher speed networks, such as 40GBASE-T requiring even more.

Table 1 defines the cabling system required, the data rate and the encoding schemes used for a number of copper-based Ethernet speeds.

The need for more bandwidth to enable an increase in data rate has seen a change in direction over the last six to twelve months. Driven by maximising the bandwidth available in millions of legacy C5e and C6 cabling systems, the Ethernet standard is experiencing something of a revolution. Gone are the days of order of magnitude speed increases. The first of the next Ethernet technologies will deliver 2.5 Gb/s and 5 Gb/s over Cat. 5E (Class D) and Cat. 6 (Class E) cabling systems respectively. These are shown on the timeline in Figure 2, along with the future development plans for 50GbE and 200GbE, delivering 50 Gb/s and 200 Gb/s respectively.

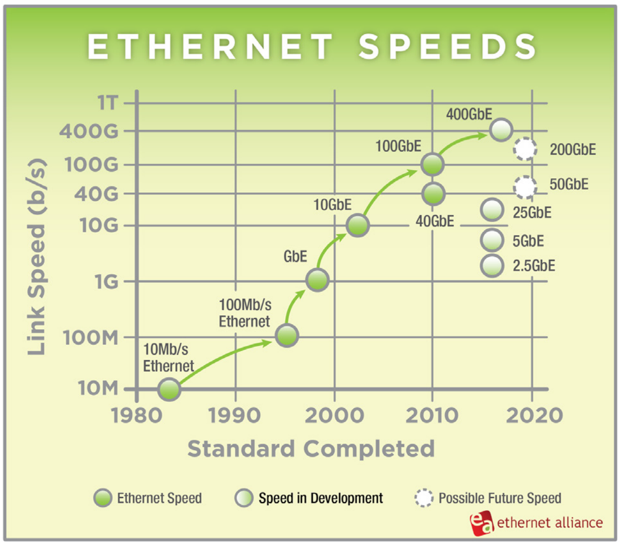

Figure 2 - Current and Future Copper and Fibre Ethernet Speeds

2.5 G & 5 G

The basic thinking behind the development and introduction of these “in between” speeds is to enable the greater utilization of the bandwidth available in the enormous installed base of Cat. 5E (Class D) and Cat. 6 (Class E) cabling systems. The current expectation is that more performance (Mb/s) can be obtained out of the installed base of copper cabling than is currently being utilised by existing Ethernet technologies. The additional available bandwidth in a typical Class E cabling system when compared to a typical Class D cabling system is why the IEEE are looking at both a 5 Gb/s and a 2.5 Gb/s solution.

[2] Tomlinson-Harashima Precoded (THP) version of pulse-amplitude modulation with 16 discrete levels (PAM-16)

The dramatic increase in the numbers and speeds of mobile and wireless devices in the enterprise is a further driver of higher speed Ethernet protocols, with Wi-Fi connections expected to exceed cabled Ethernet during 2015. If more users can be attached to, or higher speeds can be attained from, wireless access points (WAPs), then the costs of additional units can be mitigated.

Figure 3 illustrates the typical near end cross talk (NEXT) performance of a HellermannTyton Category 5 Enhanced connector when tested up to 250 MHz which is the anticipated required bandwidth for 2.5 i.e. beyond the 100MHz required by the Cat. 5E (Class D) standard. The connector shows almost 10 dBs of headroom when compared to the proposed performance requirements and is close to being Category 6 compliant. Of course, the ability of a legacy Cat. 5E (Class D), or Cat. 6 (Class E) installation to support next generation Ethernet protocols is not reliant on NEXT alone. As with the most recently introduced cabling performance level, Cat. 6A (Class EA), the cabling infrastructures needed to support future Ethernet protocols above 1 Gb/s will also need to meet Alien Crosstalk (AXT) performance levels; something that they were never designed to do.

In order for support to be available for 2.5 Gb/s and 5 Gb/s Ethernet, a significant amount of field measurement of legacy systems will be required to ensure that the advantage of using existing cabling is realisable.

Figure 4 shows the relative differences in Alien Crosstalk between typical unshielded Class D, Class E and Class EA cabling systems. The differences are obvious and significant. The elevated signally speeds of the next generation of Ethernet standards will challenge the Alien Crosstalk performance and a significant amount of research into the typical levels available in the field will have to be clearly understood before the IEEE commit to defining the full physical layer (PHY) specification.

One possible solution to Alien Crosstalk requirements is the mitigation of the cabling system through increased spacing between cables. This of course would prove challenging in all but the most trivial of installations and goes against the principle of leveraging the performance of legacy installed infrastructure. Given that Ethernet speeds will only increase over time, it also seems safe to assume that all further Ethernet protocols will require some degree of Alien Crosstalk compliance.

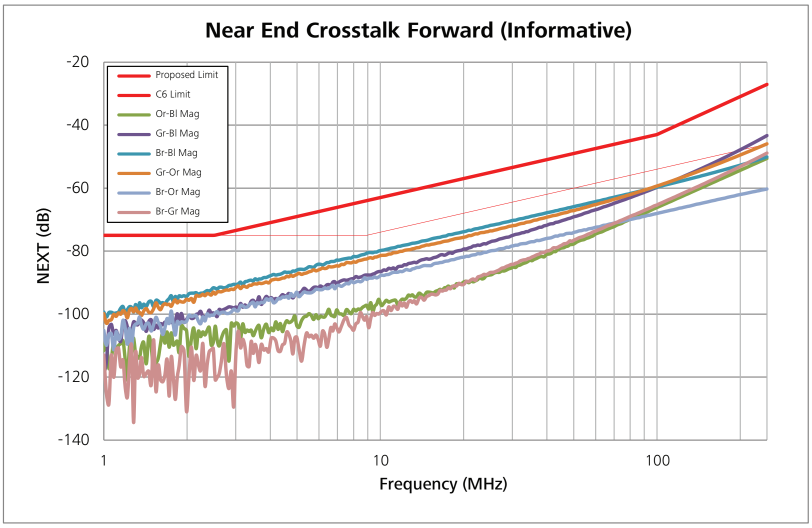

Figure 3 - NEXT Performance of HT C5e Connector up to 250 MHz

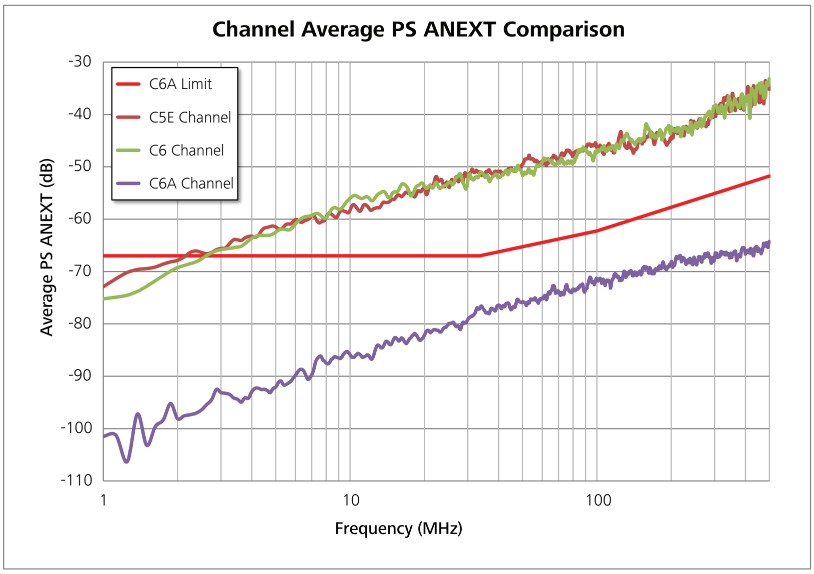

Figure 4 - Difference in AXT between Cabling Systems

One interesting point worthy of note is that the IEEE are intending to define the PHY specification up to 100 m for both 2.5 Gb/s and 5 Gb/s Ethernet speeds, unlike the change in direction taken with Category 8, where the maximum lengths are being reduced to those prevalent in modern data centres, i.e. 30 m links.

The anticipated approval date for these next generation Ethernet protocols is likely to be the end of 2016 at the very earliest, with the end of 2017 more realistic at present. That being said, we are likely to see products in the market claiming compliance prior to the official release date.

What’s next for Ethernet?

These two new Ethernet speeds are not the end of the line for copper-based cabling systems. ISO, TIA, IEEE and the Ethernet Alliance are also working on 40GBASE-T utilising Category 8 cabling with an operational bandwidth of 2 GHz. And that’s just copper developments. The implementation of Ethernet standards over singlemode and multi-mode fibre cabling is not being left behind. Present developments include multi-gigabit developments with terabit data rates on the horizon. The Ethernet Alliance’s roadmap as shown in Figure 5 and available from http://www.ethernetalliance.org/roadmap/ outlines the future plans for this most pervasive of networking protocols. Higher speed lasers as well as parallel optics will all play their part.

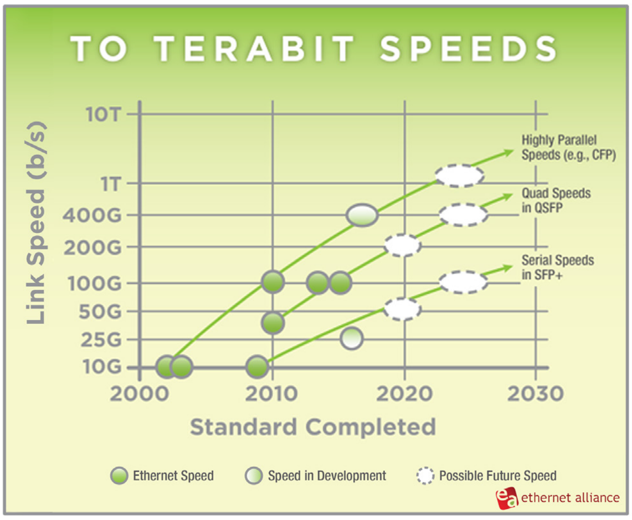

Figure 5 - Ethernet Alliance’s Roadmap

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