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Technical note #2

Presentation of existing fibers' performances and commercial transceivers

CAILabs

Shaping the light

This document presents performances of multi-mode fibers deployed in existing LANs in terms of reach capacity and different types of commercial transceivers.

Multi-mode Fiber Specifications

Different types of fiber include single-mode and multi-mode. Single-mode fibers are technologically advanced and allow only one mode of propagation. They are used for high broadband transmissions on long distances. On the contrary, multi-mode fibers were the first on the market and allow a few modes (optical paths) to propagate.
Multi-mode fibers suffer from modal dispersion, their capacity is limited for a given distance (rf. Technical note #1 for more details about modal dispersion limitations). Modal dispersion measurement allows qualifying the bandwidth of fiber to estimate the maximal distance for a given throughput. The below table presents specifications of different multi-mode fibers using the information derived from several sources (IEEE and transceivers manufacturers):

MAXIMAL REACHABLE DISTANCES (in m)		TYPE OF FIBER				
		Multi-mode				Single-mode
Throughput	Wavelength	OM1 (62.5/125 µm)	OM2 (50/125 µm)	OM3 (50/125 µm)	OM4 (50/125 µm)	SMF (9/125 µm)
100 Mb/s	850 nm	300	550	550	550	NA
	1310 nm	2000	2000	2000	2000	20000
1 Gb/s	850 nm	260	550	550	550	NA
	1310 nm	550	560	575	600	40000
10 Gb/s	850 nm	34	80	315	600	NA
	1310 nm	300*	300*	300*	300*	40000

**Distances of 300m are valid with the use of 10GBASE-LX4 transceivers (ie WDM at 1310nm). Distances of 220m are reachable with OMx multi-mode fibers by using 10GBASE-LRM transceivers. The use of adapting patch cords is required to reach these performances with -LRM and -LX4.*

CAILabs has developed a light shaping technology that avoids modal dispersion for high broadband transmissions in existing multi-mode fibers. This technology allows to transmit, in standard multi-mode fibers, throughputs of 4 x 10 Gb/s for distances up to 10 km.

Commercial Transceivers

Ethernet protocol is accepted as the standard communication protocol used in Local Area Networks (LANs). Over the years, the IEEE institute published several standards related to Gigabit Ethernet (1 GbE IEEE 802.3z) and to 10 Gigabit Ethernet (10 GbE IEEE 802.3ae).

To implement different standards of physical layers 1 GbE and 10 GbE in IT networks many optical interfaces are available. Such an interfaces is called transceiver as each one is composed of a transmitter and a receiver.

The transceiver connects the motherboard of the network equipment (such as a switch) to the fiber that transports the information. These transceivers enable flexibility in the signal type as they are hot pluggable. They allow to change signal type or bit rate by changing only the transceiver.

There is no standardization concerning transceivers but multi-sources agreements (MSA) are established. The main differences between various interfaces are cost, electrical interface, energy consumption and the form factor.

The main formats of transceivers are:

- GBIC (Gigabit Interface Converter)
- SFP (Small Form-factor Pluggable)
- SFP+ (Enhanced Small Form-factor Pluggable)
- XFP (10 Gigabit Small Form-factor Pluggable)
- XENPACK
- X2

These transceivers are classified according to wavelength, type of fiber (single-mode or multi-mode) and have different type of connectors (LC or SC).

Transceiver classifications for 1GbE:
- 1000BASE-SX: 850nm, for multi-mode fiber
- 1000BASE-LX: 1310nm, for single-mode fiber
- 1000BASE-EX: 1550nm, for single-mode fiber
- 1000BASE-ZX: 1550nm, for single-mode fiber

Transceiver classifications for 10GbE :
- 10GBASE-SR: 850nm, for multi-mode fiber
- 10GBASE-LR: 1310nm, for single-mode fiber
- 10GBASE-ER: 1550nm, for single-mode fiber
- 10GBASE-ZR: 1550nm, for single-mode fiber

For choosing a transceiver, an important feature to consider is the optical budget available on the link. The optical budget is obtained by deducting the receiver sensitivity to the power emitted by the transceiver.

Different form factors are interoperable as long as the type of physical interface remains the same on both ends of the link. For example, it is possible to deploy a fiber link with a XFP 10GBASE-ER module on the left and a SFP+ 10GBASE-ER module on the right. However, a SFP+ 10GBASE-SR module cannot be connected to a SFP+ 10GBASE-LR module on the other end of the link.

NB: Above transceivers are available for the Ethernet protocol, also for other communication protocol such as Fiber Channel and SDH.

Single-mode transceivers answering to specifications 1000BASE-LX/-EX and 10GBASE-LR/-ER are compatible with the solution AROONA.

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