Increasing capacity on multimode fiber

Multimode fiber has been installed since the early '70[s] as a convenient manner of providing bandwidth to buildings and campuses. Since then, the need for higher bandwidth has increased tremendously, leaving the original OM1/OM2 multimode fiber as a showstopper for further expansion of the network.

This Application Note presents various ways to increase the throughput of existing multimode fiber.

Limitations

OM1 (62,5 µm/125µm) and OM2 (50 µm/125 µm) fiber have been dominating the local area domain until the turn of the century, providing throughput up to 100 Mbps for up to 2 km with LED based modules. In 1998 IEEE specified the VCSEL laser succeeding the LED laser. About 70% of fibers in LANs are still multimode nowadays.

As shown in the below table both OM1 and OM2 fiber have limitations to their throughput. Some of these limits have been increased with the introduction of OM3 (standardized 2002), OM4 (2009) and OM5 (2016).

Table 1: Average distances on MMF (Source: IEEE 802.3)

Bandwidth	Protocol	OM1	OM2	OM3	OM4	OM5
1 Gb/s	1000BASE-SX	400 m	550 m	575 m	600 m	600 m
10 Gb/s	10GBASE-SR	33 m	82 m	315 m	500 m	550 m
40 Gb/s	40GBase-eSR4	---	---	100 m	150 m	440 m
100 Gb/s	100GBASE-SR4	---	---	70 m	100 m	150 m

1 Gb: Extended SFP

Itectra offers a long distance 1 Gb transceiver with 1310 nm wavelength and extended reach capabilities up to 1 km on OM1/OM2 fiber installations. This SFP will allow an on-the-fly expansion of the capacity to 1 Gb/s by replacing the SFP's.

10Gb: Various methods

Mode Conditioning Patch Cord

For best performance on OM1 and OM2 IEEE recommends the use of a Mode Conditioning Patch Cord (MCPC) together with a LRM transceiver.
Please note that LRM transceivers and MPCP are limited to 10Gbps Bandwidth.

AROONA Connect / AROONA Star

For higher bandwidth and/or longer distances Itectra offers the AROONA portfolio from Cailabs. This portfolio is built around MPLC (Multi-Plane Light Conversion) which filters out the modal dispersion in multimode fibers. By installing one or several AROONAs along the path the distance can be increased to several thousand meters, and the bandwidth can be increased up to 100 Gb/s.

AROONA also enables the potential to use xWDM, Passive Optical LAN and Bidirectional transmission on your legacy multimode infrastructure.
AROONA CONNECT is the plug'n'play version of the AROONA STAR featuring connectors at both ends.
The user-friendly AROONA CONNECT covers distances up to 550 m without requiring a high ER value.
This product is a simplex solution.

For cases featuring longer distances, higher bandwidth and/or with many patches, it is recommended to install the AROONA STAR. This product is a duplex solution.
For optimal performance it is advisable to utilize an EML laser, as this laser type features a higher Extinction Ratio (ER) tolerance.

Performance

Performance on multimode installations may vary due to various factors such as splices, dispersion, accumulated contamination disturbing the signal. This may impact the performance in various manners.

Table 2: Extended distances on MMF[†], measured in km (Source: Cailabs, Wikipedia: Multi-mode_optical_fiber)

	1GbE			10GbE			40GbE			100GbE		
	OM1/ OM2	OM3	OM4/ OM5	OM1/ OM2	OM3	OM4/ OM5	OM1/ OM2	OM3	OM4/ OM5	OM1/ OM2	OM3	OM4/ OM5
SFP (1km)	1.00	1.00	1.00	---	---	---	---	---	---	---	---	---
MCPC	---	---	---	0.22	0.22	0.22	---	---	---	---	---	---
Connect	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	---	---	---
1×Star[‡]	0.80	0.80	0.80	0.80	0.80	0.80	0.60	0.60	0.60	0.40	0.40	0.40
2×Star[‡]	10.0	10.0	10.0	10.0	10.0	10.0	6.00	6.00	6.00	1.50	1.50	1.50

[†]: Subject to the complexity and condition of the link

[‡]: OTDR is mandatory for verification of the condition of the link.

The above table shows recommended distances on different multimode fiber installations through the different technologies described. The below sketch depicts the recommended set-up to minimize traffic disturbance and maximize covered distances. Real tests are recommended to be performed in all cases.
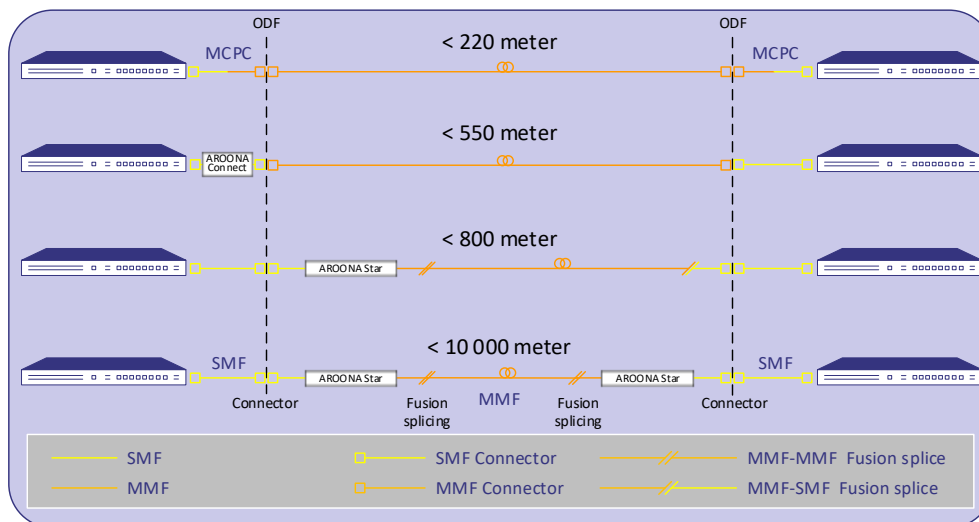
Case stories and datasheets

In our case stories where the municipality of Frederikssund and Sorø both has multiplied their utilization of already installed multimode fibres.

Please contact Itectra – or refer to www.itectra.com – for more information.

Technical specification

Product	AROONA Connect	AROONA Star
Reach	≤ 550m (AROONA Connect @ one end)	≤ 800m (AROONA Star @ one end)
		≤ 10 000m (AROONA Star @ both end)
Fibre type	SMF: G.652D / MMF: OM2	SMF: G.652D / MMF: OM1 SMF: G.652D / MMF: OM2
Legacy fibre compatibility	OM1 / OM2 / OM3 / OM4 / OM5	
Nº of fibres	1	2 / 4 / 6 / 8 / 12 / 24
Insertion loss	≤ 2.5 dB (typ.: 2.0 dB)	≤ 2.0 dB (typ.: 1.5 dB)
System capacity[†]	1 Gbps – 40 Gbps	1 Gbps – 100 Gbps
Protocol & NW	Compatible to GPON, XGPON, XGSPON and WDM Passive device transparent to any communication protocol	
Wavelength	1250 nm – 1600 nm	
Transceiver capability	Duplex or Bi-directional SM transceiver (1000Base-LX/EX, 10GBase-LR/ER, 40GBase-LR4/ER4)	Duplex or Bi-directional SM transceiver (1000Base-LX/EX, 10GBase-LR/ER/ZR, 25GBase-LR/ER, 40GBase-LR4/ER4, 100GBaseLR4/CWDM4, etc.)
Packing	Total length: 3 m +/- 20 cm Tube (w/o cable boot): Length: 125 mm, ø: 7.5 mm Tube (w/ cable boot): Length: 180 mm, ø: 7.5 mm Single-mode fiber length: 0.5 m ±100 mm, Multimode fiber length: 2.5 m ±100 mm Fiber tubing (SMF/MMF): ø: 3 mm	Compact module (2 fibre version): ST/SC/LC (UPC) connector on the SMF side. Open-end MMF on the rear panel for splicing. 9'' 1U rack (4/8/12/24 fibre versions). LC/UPC connector on the front (SMF). Open-ended MMF on the rear for splicing.
Operational temperature	-40°C - +70°C (ETSI EN 300 019-1-3 class 3.4)	
Transport tolerance	ETSI EN 300 019-1-2 class 2.3	

Ordering information:

P/N	Nº fibre	SMF	MMF	P/N	Nº fibre	SMF	MMF
				C1SAMAM2	1 × OM2	LC/UPC	LC/UPC
				C1SAMDM2	1 × OM2	LC/UPC	ST/UPC
				C1SBMAM2	1 × OM2	SC/APC	LC/UPC
S2DM1	2 × OM1	ST/UPC	Open ended	S2DM2	2 × OM2	ST/UPC	Open ended
S2CM1	2 × OM1	SC/UPC	Open ended	S2CM2	2 × OM2	SC/UPC	Open ended
S2BM1	2 × OM1	SC/APC	Open ended	S2BM2	2 × OM2	SC/APC	Open ended
S2AM1	2 × OM1	LC/UPC	Open ended	S2AM2	2 × OM2	LC/UPC	Open ended
S4M1[‡]	4 × OM1	LC/UPC	Open ended	S4M2[‡]	4 × OM2	LC/UPC	Open ended
S8M1[‡]	8 × OM1	LC/UPC	Open ended	S8M2[‡]	8 × OM2	LC/UPC	Open ended
S12M1[‡]	12 × OM1	LC/UPC	Open ended	S12M2[‡]	12 × OM2	LC/UPC	Open ended
S24M1[‡]	24 × OM1	LC/UPC	Open ended	S24M2[‡]	24 × OM2	LC/UPC	Open ended

[†]: Subject to the complexity and condition of the link

[‡]: Chassis-mounted version