cailabs

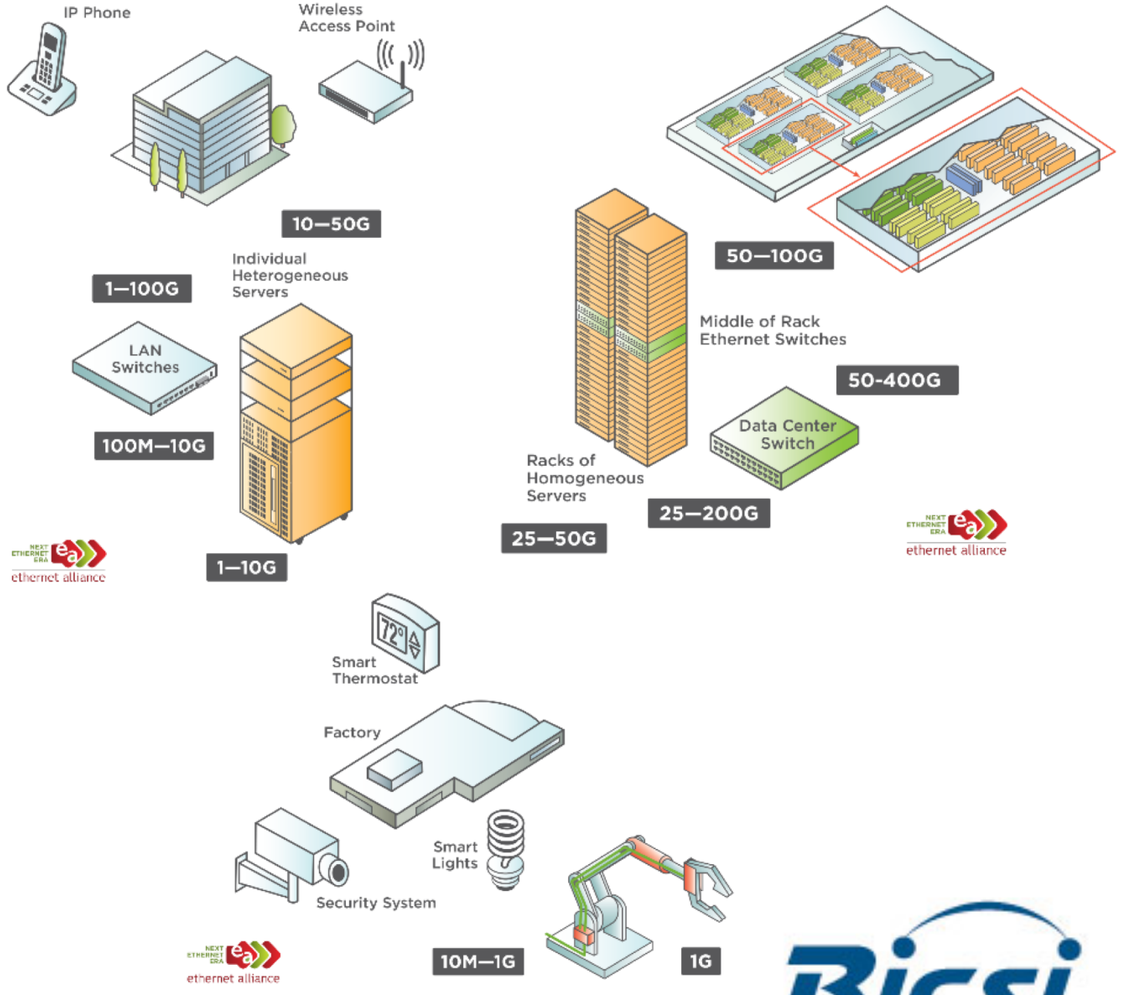
Campus Fiber Infrastructure: The Limitations and how to Future-proof it

Is transforming multimode fibers into singlemode fibers possible?

Bicsi

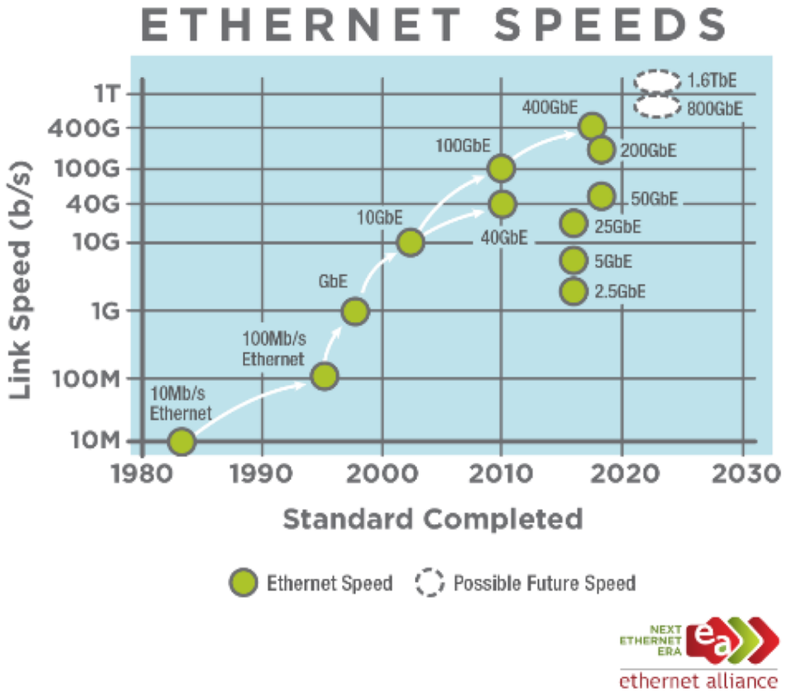
Bandwidth consuming apps in the LAN

- WiFi (802.11ac up to 7Gb/s)
- VoIP, video-conference
- CCTV
- Virtualization, cloud computing
- Connected objects, BYOD
- Consumer/industrial IoT up to 20Gb/s
- Smart building, smart factory, etc.
- …



Increased bandwidth capacity needs

- New standards mean more bandwidth and versatility for tomorrow's Ethernet networks



Bandwidth-intensive applications + latency-aware traffic types

- **LAN cabling infrastructures need to support ever-growing bit rates**

Multimode fibre

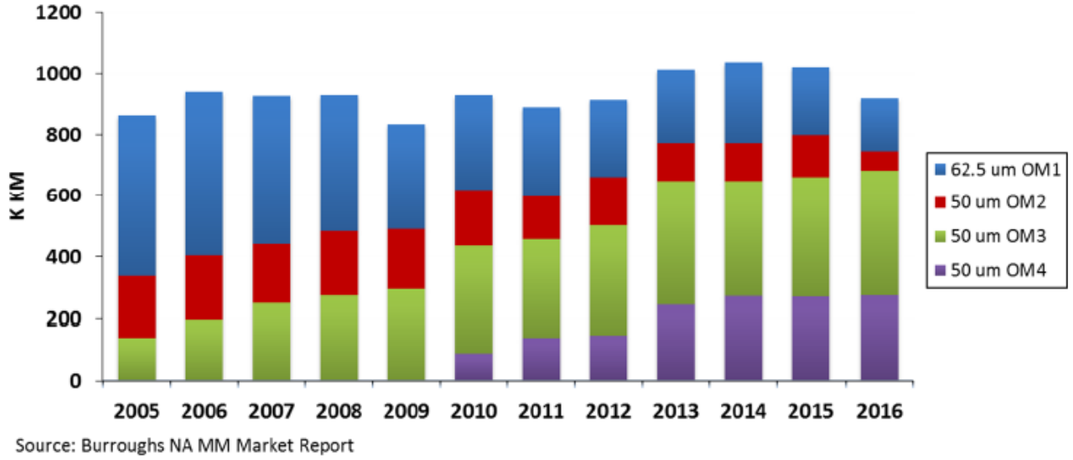
=

MMF everywhere but bandwidth limited

75% of fibres in LAN are **MMFs**

35% exisiting MMFs are **limited to 1 Gb/s** (or 100 Mb/s max)

→ Today's need over LAN backbone: 10 Gb/s



Source: Burroughs NA MM Market Report

Maximum reach over MMF (at 850nm)	100 Mb/s	10 Gb/s	40 Gb/s
OM1 (62.5/125 µm)	2000 m	**33 m**	N.A
OM2 (50/125 µm)	2000 m	**82 m**	N.A
OM3 (50/125 µm)	2000 m	300 m	100 m
OM4 (50/125 µm)	2000 m	400 m	150 m

Limited bandwidth = Maximum reach decreases when bit rate increases

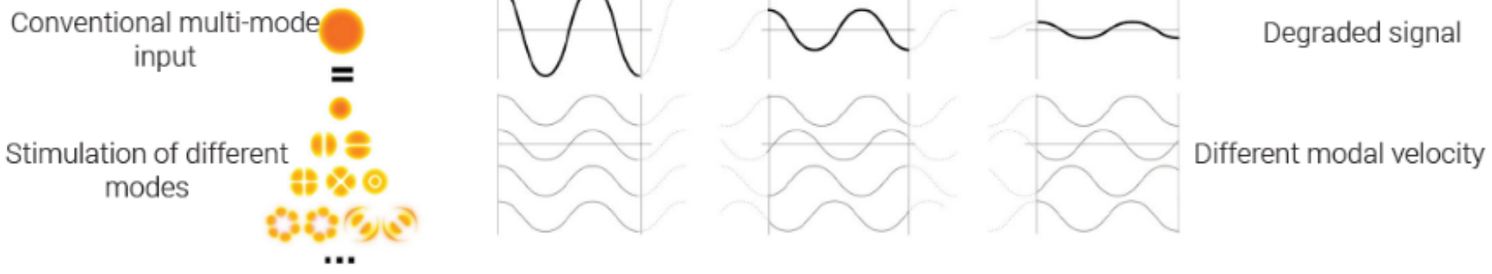
- The cause of this limitation: **modal dispersion**

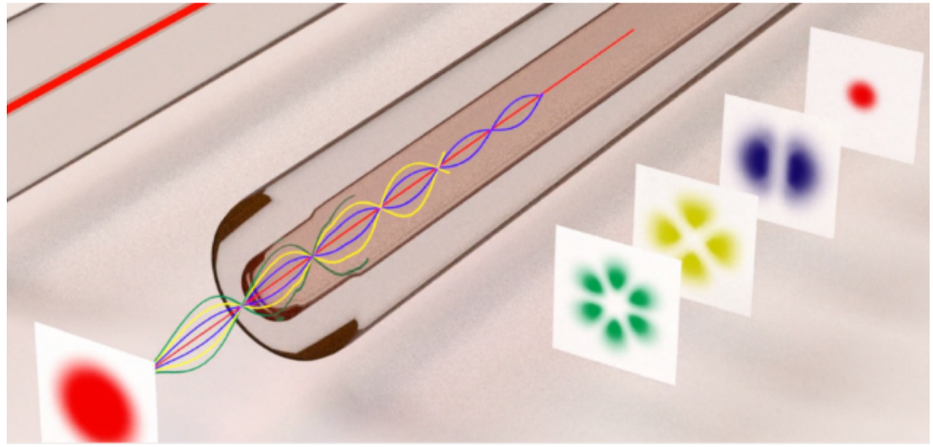
Modal dispersion

Distorsion mechanism of optical pulse occuring in multimode fibres during propagation

Different modal speeds

Leads to poor transmisison quality for high bit rates (degraded bit error rate)





UPGRADING NETWORKS BY OVERCOMING THE MMF LIMITATION ISSUE

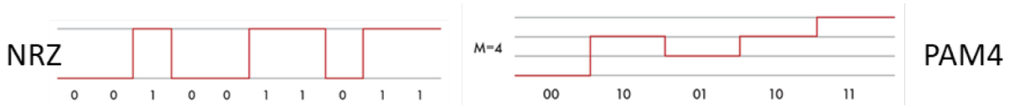
Advanced Modulation format

Increase spectral efficiency but very expensive

Use complementary properties of light

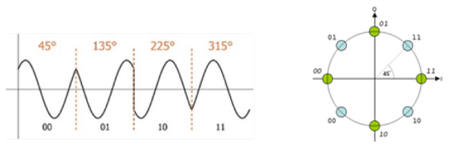
Power

PAMx (Pulse-Amplitude Modulation)



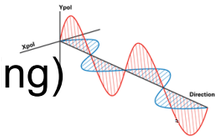
Phase

xPSK (Phase Shift Keying)

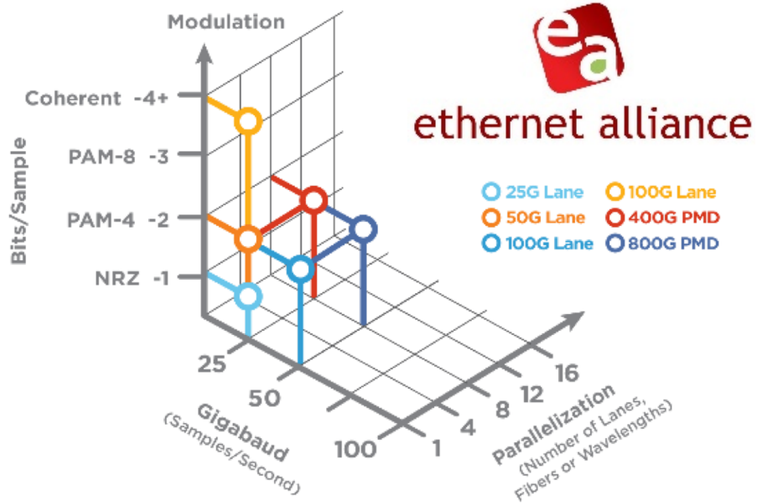


Polarisation

PDM (Polarization Division Multiplexing)



Coherent transmission used for long distance links



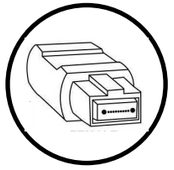
➔Need very expensive Active equipment

Not compatible with the economic model of LAN

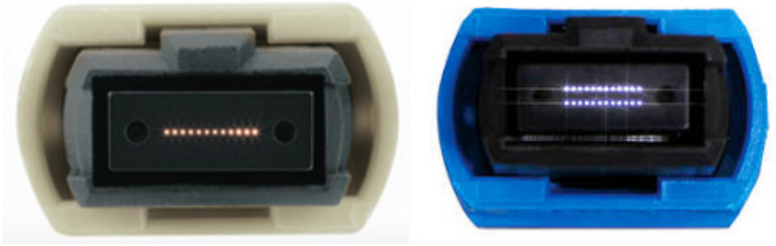
MMF Parallelisation

Not applicable for Network upgrade

Bypass bandwidth limitation with parallelisation of several MMF



Multi-Fibers connectors (MPO/MTP) 8 to 72 fibers
Transceivers QSFP 40G-SR4, 100G-SR10, etc



➔Maximum capacity of each fiber remains the bottleneck

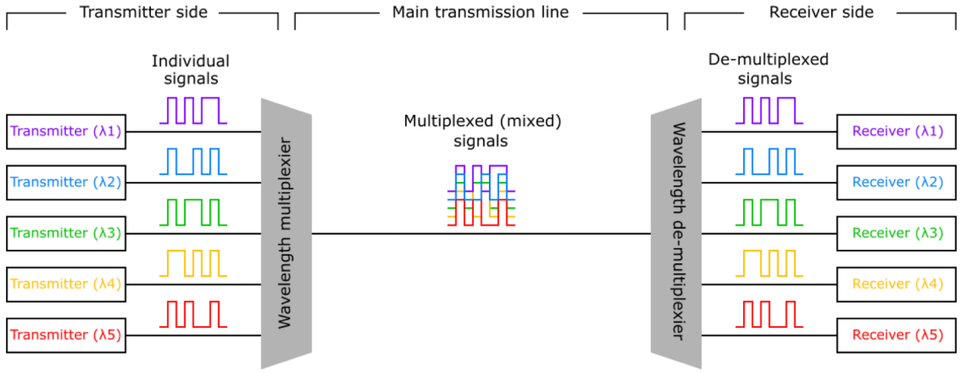
Not applicable (or rarely) for existing LAN network upgrade

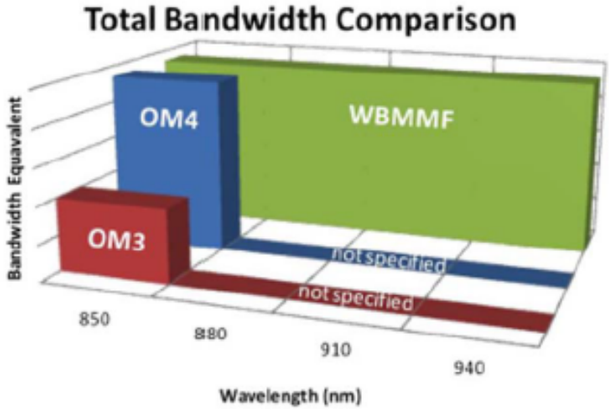
Wavelength division multiplexing (WDM)

WDM

Allows creation of several channels within a Single fibers pair by sending several wavelength

Could be integrated within a transceiver
ex. 100GBASE-LR4 (4x25Gb/s)
Also exists as SWDM (Short WDM)
on OM5 fibers (Wide band MMF)





➔Maximum capacity of each channel remains the maximum capacity of the fiber
➔Add complexity for maintenance purposes and Transceivers stock management

Deploy New Fibers

Could be very expensive and time consuming

Remplace existing MMF with last generation Fibers such as Single Mode or OM4/5

Increase Link capacity
Perennity of the solution if SMF

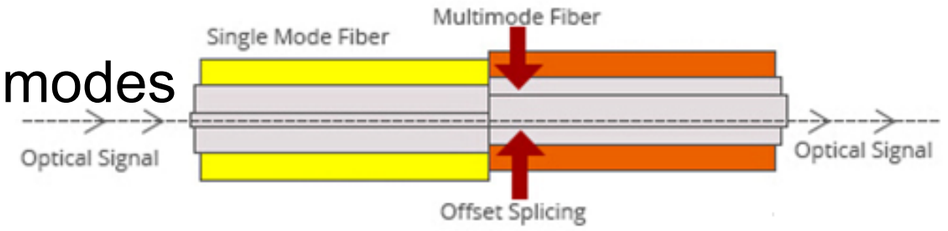
BUT
Infrastructure audit / site survey needed (Availability and access to cable Tray required)
Installation could be time consuming and complex
Street work possible
Potentially expensive and complex, sometimes not realistic

IEEE 802.3aq

Increase a bit the capacity but no Warranty

« offset launching » process

« mode-conditioning » patchcord to excite less modes
And as such reduce Modal Dispersion
pour exciter moins de modes donc



LRM + EDC

LRM (Long Reach Multimode) Transceivers for signal treatment, electronic compensation of dispersion (EDC)

10 Gb/s « potentially » up to max 220 m on OM1 or OM2
No guarantee of success, depends upon MMF connectors quality,
Limited capacity improvement

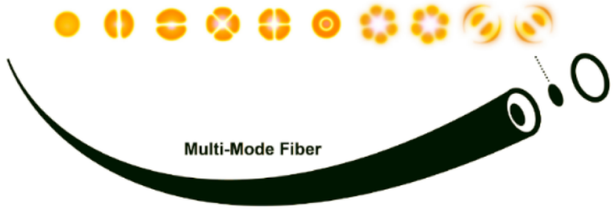
Overcoming MMF limitations

Pros & Cons of existing alternatives:

Alternative	**Modulation**	**Parallelization**	**Multiplexing**	**Deploying fibers**	**Light launching conditions**	
Objective	Increased spectral efficiency	BW limitation bypassed with MPO	BW limitation bypassed with several WDM channels	Latest generation fibres (OM5/SMF)	Reduced modal dispersion (LRM+EDC)	Removed modal dispersion impact (MPLC)
Fiber capacity gain	+	-	+	++	+	++
Cost	--	+	-	- to --	++	++
Ease of deployment	+	+	+	- to --	++	+
Ease of operation	-	+	-	++	++	++
Suitable for upgrade	Yes	No	Yes	Yes/No	Yes	Yes

A new dimension: the shape of the light

It is possible to **avoid modal dispersion by coupling and detecting precisely the modes within the MMF**.



MPLC : Multi-Plane Light Conversion technology

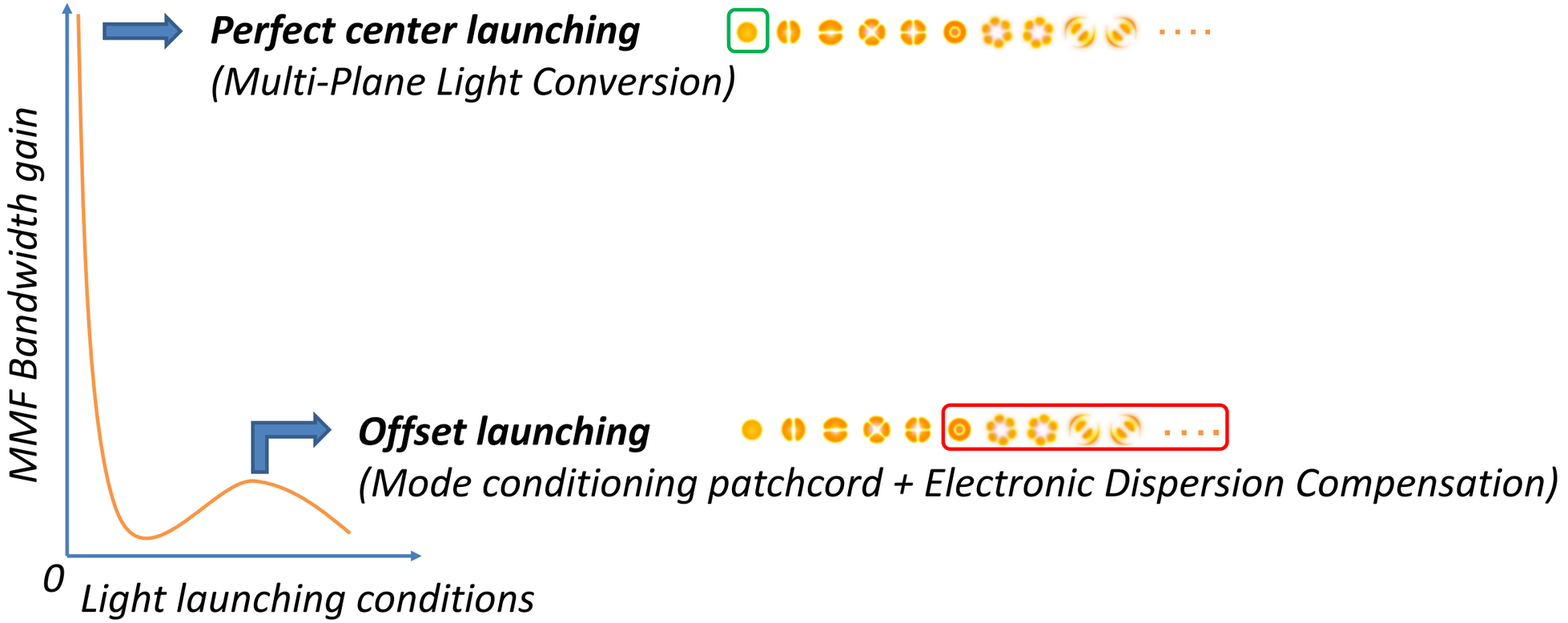
- **passive optical process** derived from quantum optics **to shape the light**

Solution to increase bit rates :

- **Excite only one mode** to have a **single-mode transmission over multimode fibres**

Addressing modes inside MMF

Theoritical MMF bandwidth gain according to launching conditions (extract from IEEE 802.3aq study)



Remove MMF bandwidth limitation

Increased capacity

High capacity channels (10+ Gb/s), **WDM compatible**

Adaptable to the network topology (point to point, star, POL)

Compatible with standard fibers and transceivers

Any type of **multi-mode fibre 62.5/125 µm or 50/125 µm (up to 10km)**

Any type of **single-mode transceiver; Transparent to communication protocol**

Ease of installation - Reduced cost

3 times less expensive than a fibre roll-out; **up to 10 times** less expensive if complexities exist

Installation takes **only few hours**

Passive system: no additional cost of consumption, cooling, monitoring

Why using this new technology?

Innovative solution

Gain a competitive edge by providing a cutting-edge technology

New clients

By differentiating your company from competition

Short sales cycle

Closing deals quickly due to less operationnal constraints

Alternative to recabling

Upgrade possible if certain links too expensive or technically constraining for installers

Ressources

Easy installation / fewer human ressources → increase margin

Tender

Secure the whole contract by adding this technology to tender response

Modal dimension tested and validated

100 Gb/s CWDM4 over 1km OM1 with modal adapter

160 Gb/s over 1km OM4 with SDM

14.5 Tb/s over 2200 m OM2

100 Gb/s CWDM4 over 2km of OM1

160 Gb/s over 2km OM3

GPON & XG-PON1 transmission over MMF

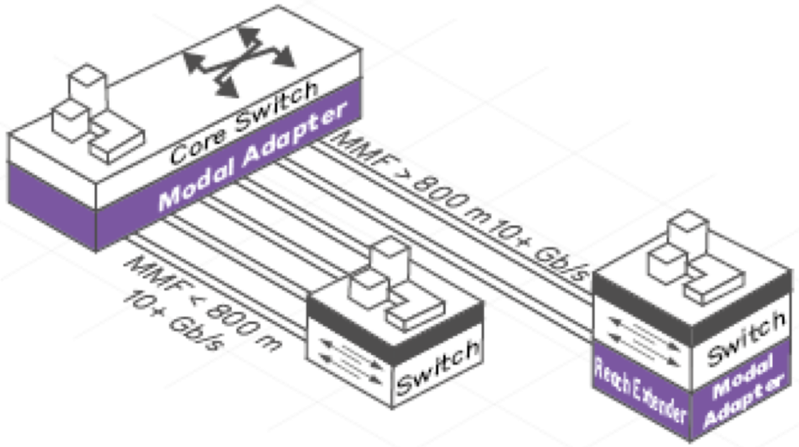
GPON & XGS-PON transmission over MMF

How implement modal adapter?
(for standard Ethernet LAN)

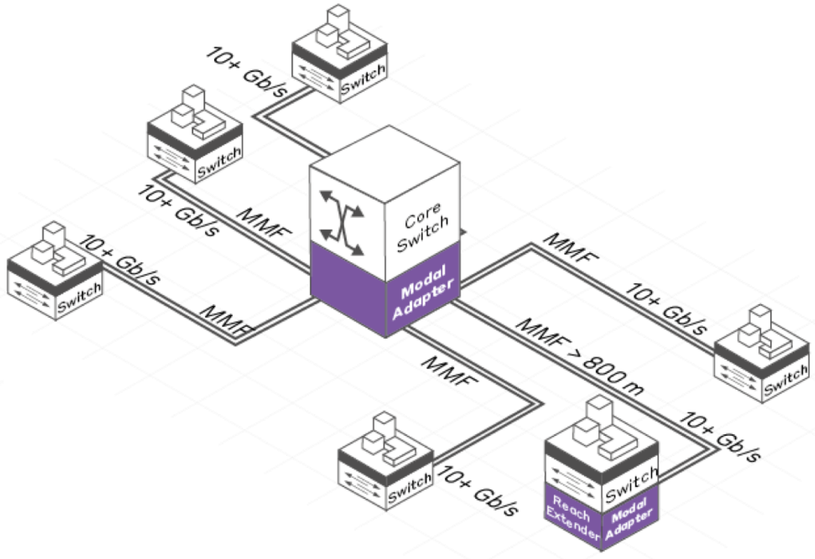
Upgrade several MMFs of the network with a single component

Only at the core of the network - No installation required at remote sites if links < 800m

Reach extender modal adapter to extend **to 10km high bit rates MMF link**



Over Point-to-Point topology



Over Star topology

Futur proofing a factory network

MPLC enabled a steel industry to upgrade its CCTV system and to implement its smart factory program

OM1 fibre backbone

5 links between **900 to 2200m**

No free cable conduit under building and parking

SEVESO site = complexties for civil engineering

- **10 Gb/s** enabled **+ CWDM** implemented
- Light project management & prevention plan
- **Neither construction work** nor production line on-site interrupted
- **New client** for the system integrator thanks to innovative solution

Broadband for university campus

MPLC enabled Georgia Tech to implement high bit rate MMF network within campus and Student Accomodation Building

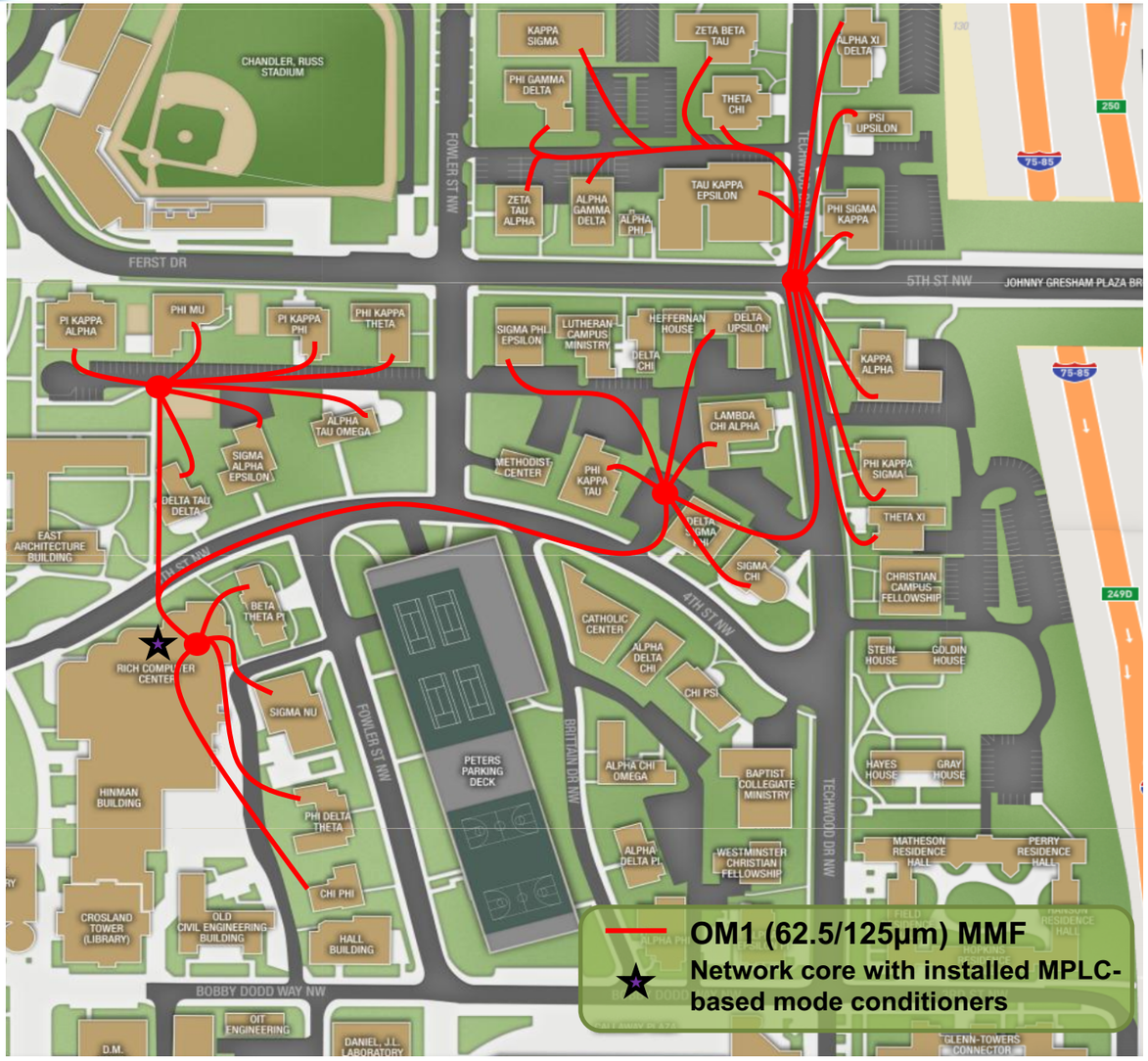
Cabling not an option due to project cost

OM1 fibre backbone (star topology)

35 remote buildings between **400 and 1100m**

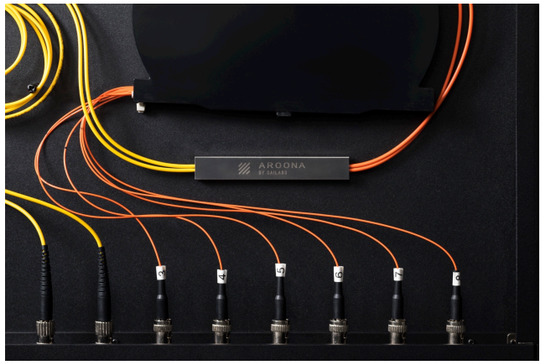
- **10 Gb/s** throughput available
- Project-enabler / Ease of installation
- Big margin for installer

Broadband for university campus



"All buildings are up and running on 10Gb/s network speeds. It is pretty cool to have magical technology in use and functioning so well!"

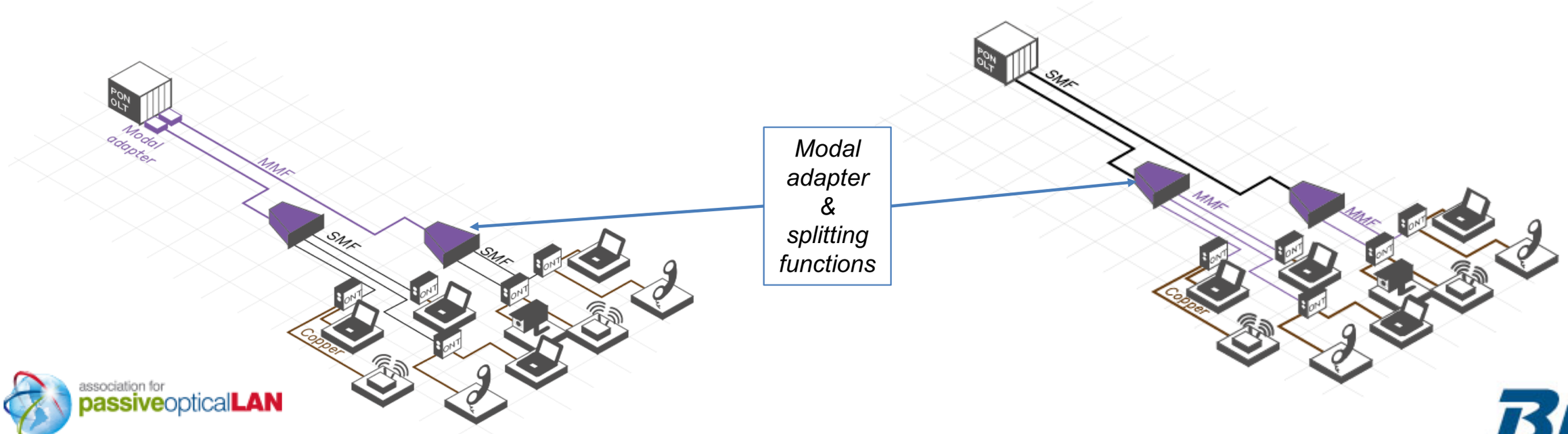
R.Toledano, Network engineer



How implement modal adapter? (for Passive Optical LAN)

Controls the **spatial modes coupling** and **adapts MMFs to SMFs by simple replacement of an optical splitter**

Facilitates the **transition to Passive Optical LAN on existing cabling infrastructure** (GPON and XGPON over MMF)



association for passiveopticalLAN

Bicsi

Transforming MMF into SMF, it is possible !

Local Area Network fiber infrastructure **mainly composed of multimode fibre**

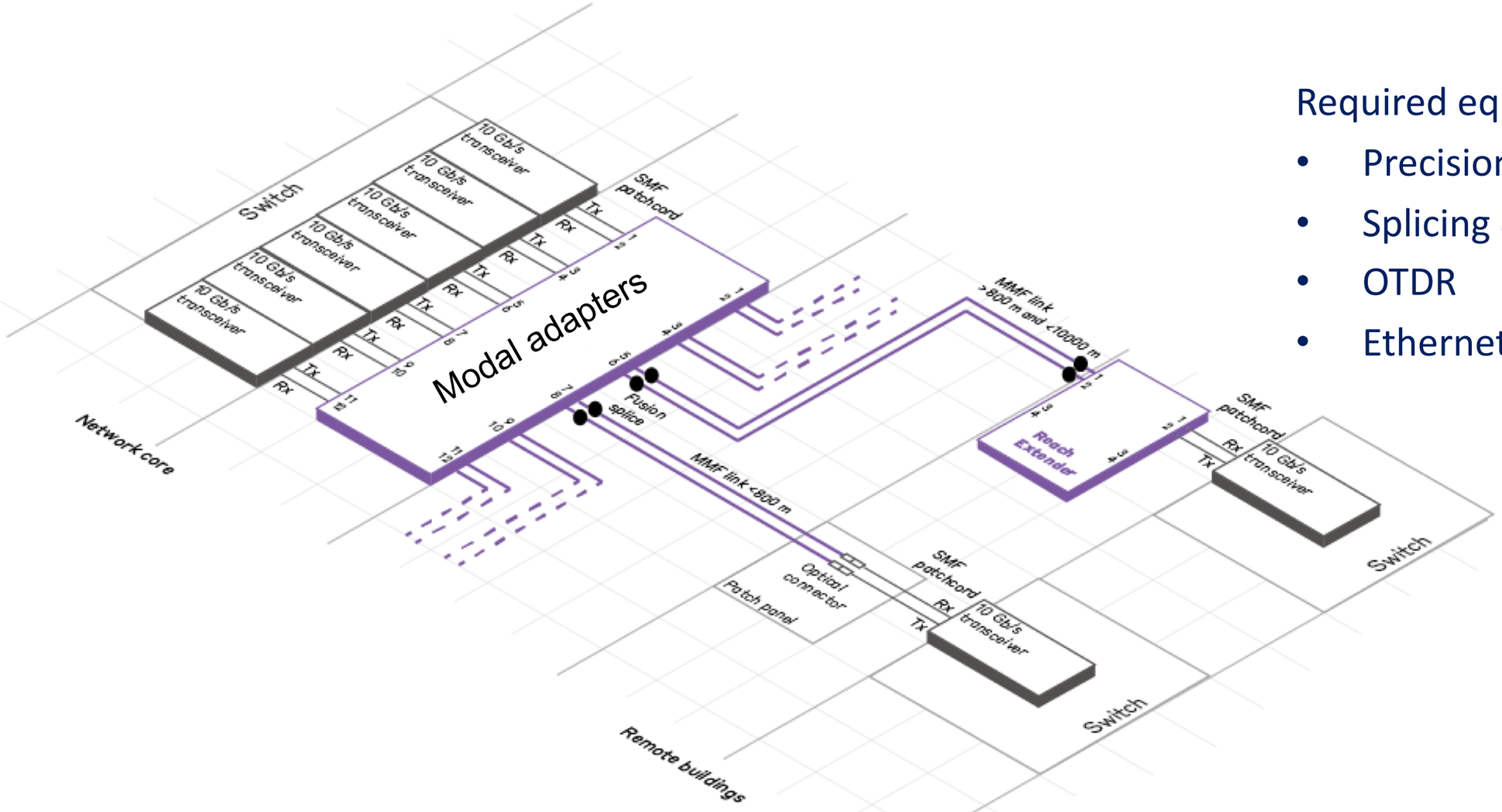
MMF = bandwidth limitation (due to modal dispersion)

Depending on the need, **on the shelf solutions to overcome MMF bandwidth limitation** (advanced modulation, parallelization, cabling, mode conditioning, MPLC modal adpater)

MPLC (Multi-Plane Light Conversion)

- **Alternative to complex fiber (re)cabling** with advantages for installers & end-users
- Light shaping innovative passive technology **to harness the full potential of MMF**
- **Overcome modal dispersion to increase MMF capacity**

Annex : How implement modal adapter?
(for standard Ethernet LAN)



Required equipment & skills:

- Precision cleaver and splicer
- Splicing & Dressing splice tray
- OTDR
- Ethernet tester

Any Question ?

Thank You

Multumesc si bun apetit

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