Introduction

Ten or so years ago there were only two types of fibre, multi-mode or single-mode, and people rarely got them mixed up. Single-mode was for the carriers to run down the street and multi-mode was for running around your premises. Forward to today and there are now 4 types of multi-mode fibre and the performance of multi-mode is catching single-mode in some situations.

It's the different types of multi-mode which causes confusion and leads to some unique issues.

Types of Multi-mode

Depending on the age of your fibres, the first issue will be the size of the multi-mode fibres.

OM1 – 62.5/125 µm
Looking back to 10+ years ago, this was the most common form of fibre. The 62.5 refers to the size of the fibre's core, which carries the light, in micrometres (µm, also known as microns). This fibre technology was based around lower cost LED based SFPs and thus reduced the cost to the point it became popular.

OM2 – 50/125 µm
This was the next form of multi-mode released, with a slightly smaller core of 50 microns, which gave much better performance for 1Gig transmission. This still uses LED based SFPs so the cost remained low.

OM3 – 50/125 µm
This fibre type has become increasingly popular in the last few years due to its ability to support 10Gig and 40Gig over useful distances. This uses the same core size as the one above and also uses the same wavelength of light (850nm) but the difference is that OM3 is optimised for VCSEL based SFPs, which are laser based rather than LEDs. This gives a more precise launch of light into the fibre, hence the better performance.

OM4 – 50/125 µm
This (at the time of writing) is the latest form of multi-mode fibre, still based on 50micron core size but the actual fibre itself is of an increased specification. The connectors and SFPs are the same as OM3 but the OM4 fibre has a tighter modal dispersion, which increases the distances it can perform at the higher speeds. Looking on the web some sites are offering OM4 with potential distances greater than the chart below. One limitation is the jitter (variations in time) between the 4x10Gig channels which make up most 40Gig connections. Some sites are claiming their SFPs have tighter performance hence giving distances of 150meters.

Applications	Wavelength (nm)	OM1	OM2	OM3	OM4	OS1
		62.5µm	50µm	50µm	50µm	9µm
100 BASE SX	850	300 m	300 m	300 m	300 m	-
1000 BASE SX	850	220 m	550 m	550 m	550 m	-
1000 BASE LX	1300	550 m	550 m	1000 m	1000 m	2000 m
10G BASE SX	850	32 m	86 m	300 m	550 m	-
10G BASE LW	1300	220 m	220 m	220 m	220 m	2000 m
10G BASE LX4	1310	300 m	300 m	300 m	300 m	2000 m
40G BASE SR4	850	-	-	100 m	125 m	-
100G BASE SR4	850	-	-	100 m	125 m	-
40G BASE LR4	1310	-	-	-	-	2000 m
100G BASE LR4	1310	-	-	-	-	2000 m

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Single Mode

OS1 – 9/125 µm

This type of fibre is defined by the 9micron core, which requires a laser based SFPs. The advantage here is the distances they can support, especially at the higher speeds. The disadvantage is the costs of the fibre and the SFPs.

The Colour of Fibre

When you look at a patch panel these days, most of them contain a mixed bag of colours which can cause alarms to go off in our head. If you look at the standards there are actually proposed colours for the different fibre types:

- OS1 – Yellow
- OM1 – Orange
- OM2 – Orange
- OM3 – Aqua
- OM4 – Aqua

However, there are complications with this, mostly because it's not followed closely by manufacturers, in fact barely followed at all at times. The military specified grey cable jackets for most of their fibre, hence certain factories just produce grey cables for everyone.

Generally, the yellow for single mode and the aqua for OM3/4 seem to hold true pretty well, the other two can be a bit random. Hence when we see a mixture of coloured patch leads in a patch panel, all could be fine or it could be a big issue, but you actually have to read the labels to find out. If it's behind the patch panel, and you don't know what the installed fibre itself is, then life is harder still and you are into testing to find out.

Issues with Fibre

A very common problem with fibre is dirt. Many fibre cores have been in place for years before they get made live, dust caps go walk about, and the quality and condition of the end faces can really be anything. The difference in performance between a clean end face and a dirty or damaged one, can be huge. Proper cleaning kits are cheap, so don't skimp on this part.

Next comes connectors. There are no standards or rules as to which ones are used, they all work, typically people end up with a mixture over time. In the beginning there was ST, then with development in manufacture for space and ease of use along came SC, then LC which are smaller and take up less space in the patch panel. It doesn't matter what you have, however if you are buying a tester, just make sure you have the correct patch/launch cords to plug in to all the different connector types you have.

However, by far the growing issue with fibre is people mixing their multi-mode types – using a different patch lead to the installed fibre. Sometimes this has more of an impact than others:

- Mixing OM1 with anything else – due to the change in core sizes, this situation causes either a big loss of power (big core to little core) or a gain in power but loss of modal control (little core to big core). Either way these links can still lock up and work but start to misbehave due to the light not being controlled properly. This can be seen as high numbers of FCS errors or the link dropping unexpectedly.
- Mixing OM2 with OM3/4 patch leads – This will probably work OK but the link performance will be based around the OM2 cores hence might not give you the distances you were expecting.

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- Mixing OM3 core with OM2 patch leads – This is happening more as people buy their patch leads on price. Effectively the loss across the patch lead will be higher than expected but realistically this will only be an issue if you are at the limits of the allowed distances.
- OM4 installations – this fibre is actually different to the other fibre types so if you want the performance of OM4 links everything must be OM4. Plug OM3 leads on the end of an OM4 run and you'll get OM3 performance - but then why pay for OM4 in the first place?

How to understand your fibre?

When it comes to a specification for running networks over fibre the real issue is the amount of loss that's allowed from one end to the other. As long as the light turns up in a form that the receiver can understand, then things will work. However, talking in db's is never popular, so these loss allowances get translated in distances, which is more user friendly. Some websites talk in terms of a power budget, allowing so much loss for the fibre plus a fixed figure for every join and splice. Therefore, it should be possible for you to calculate the loss on your link (assuming you have an idea of length and the number joins) and be able to design your network accordingly.

The allowances in these power budgets tend to be very broad, hence quite a few of the networks we test which are out of specification in terms of the length, are actually comfortably inside specification in terms of loss. However, this needs a note of caution.

What is happening in modern networks is a number of events (joins or splices) are well inside the individual budget figures but one of those events will be producing a very high loss. However, at the end of the run, the total loss of the fibre link appears to be inside the total budget. This can lead to a basic fibre tester showing a pass when in fact one part of the link has a problem and the link possibly doesn't work correctly, or is hiding an incredibly weak spot that could fail at any moment.

The different fibre testers

Most people plug the fibre up and if it works its assumed to be OK. However, as network speeds are increasing the margin for error here is being squeezed. The danger is that you are on the limit and the link is live but struggling.

Basic Light Loss tester

By this we mean you have a source and a receiver and you plug them back to back to get a reference, then run them over the link to get a loss. In theory this is all you need to Pass a link but in practise it can give false positives; it could pass links that should fail if a more detailed test was run. This type of tool also provides no diagnostics at all it, it merely reads a loss level which sometimes isn't helpful if the link shows poor performance yet light still gets through. We advise you look at the Fluke Networks SimpliFiber.

Certification tester

There are more advanced Light Loss testers on the market and these have Pass/Fail criteria, so you can certify installations. You select within the tester the standard you want to test the link to and the tester will issue you with a PASS/FAIL certificate at the end. These are easy to use and understand and popular with installers as strictly speaking this is the minimum requirement to certify fibre cables and produce a warranty on installation. However, they cannot pick up individual events and do not give distance to events and/or breaks (as the basic standards do not require these measurements). Consider the Fluke Networks CertiFiber.

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OTDR (Optical Time Domain Reflectometer)

To get a performance reading on every event in the link, with a distance to each and any other damage to a fibre cable, you need to use an OTDR. The principle here is to launch a bright pulse down the cable and analyse the reflections to see what's going on. The results that come back offer individual event measurements at every single connection and splice, which not only helps in the troubleshooting process but also allows you to audit how the fibre is all connected together. Private network owners should all have an OTDR as it allows them to quickly understand the link properly and troubleshoot exactly where the issue is. Take a look at the Fluke Networks OptiFiber – this also gives a Pass/Fail reading for Tier 2 certification, the much more comprehensive certification standard.

Summary

There are six main points to remember:

- Mixing 62.5 and 50 cores is a big no.
- Specifying 50micron Multi-Mode is not a guarantee of anything.
- There is meant to be a colouring scheme for identification but you can't trust it, so never assume.
- Ensure your patch lead and installed fibre are the same standard.
- A light loss measurement is a good start but actually can be misleading and certainly no use what so ever if there is a poor join or fault - for troubleshooting fibre you need an OTDR.
- Invest in a cleaning kit for your end-faces.

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