Fibre Channel Cabling

Live Webcast
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FCIA
FIBRE CHANNEL INDUSTRY ASSOCIATION

Today's Presenters

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Fibre Channel Cabling

This webinar is for anyone with questions concerning cabling in a Fibre Channel environment, specifically those who are directly or indirectly responsible for SAN cable plant design based on the 16GFC and Gen 6 Fibre Channel SAN platforms.

Topics discussed include:

- FC cable plant design process
- Common Cabling Components
- Copper and Fiber Optics Breakdown
- Reusing Optics
- Bit Error Ratios

Topics **not** discussed include:

- Polarity
- Upper FC Layers
- Link Loss Budgets
- Everything else

How Do I Design a Cabling Infrastructure for a Fibre Channel Storage Area Network?

Fibre Channel SAN Cabling Infrastructure

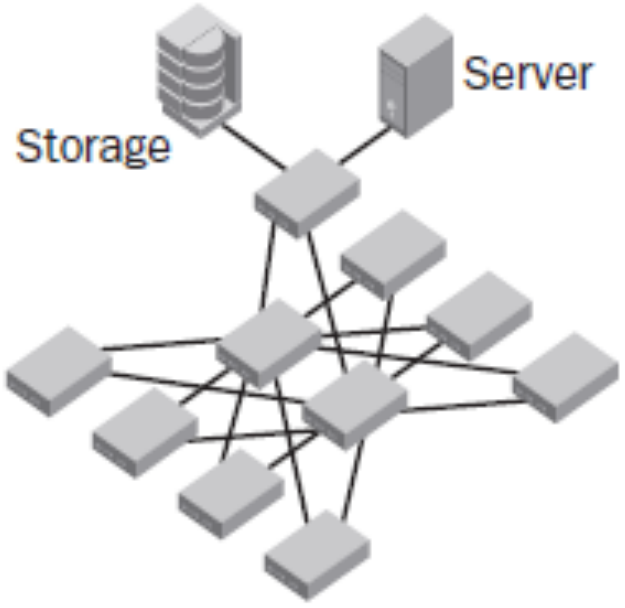
Every cabling system is unique. This is due to variations in:

- The architectural structure of the building, which houses the cabling installation
- The cable and connection products
- The function of the cabling installation
- The types of equipment the cabling installation will support -- present and future
- The configuration of an already installed system (upgrades and retrofits)
- Customer requirements
- Manufacturer warranties

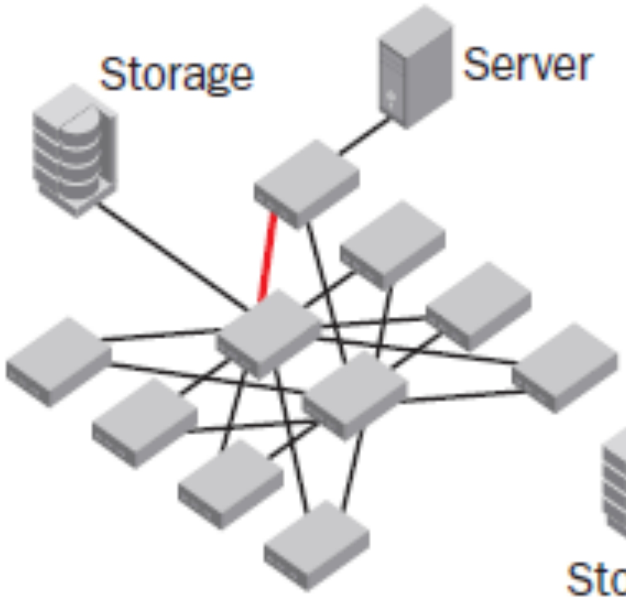
The design goal should be to ensure simplicity for easier management, future expansion, and serviceability.

Fibre Channel SAN Network Topologies

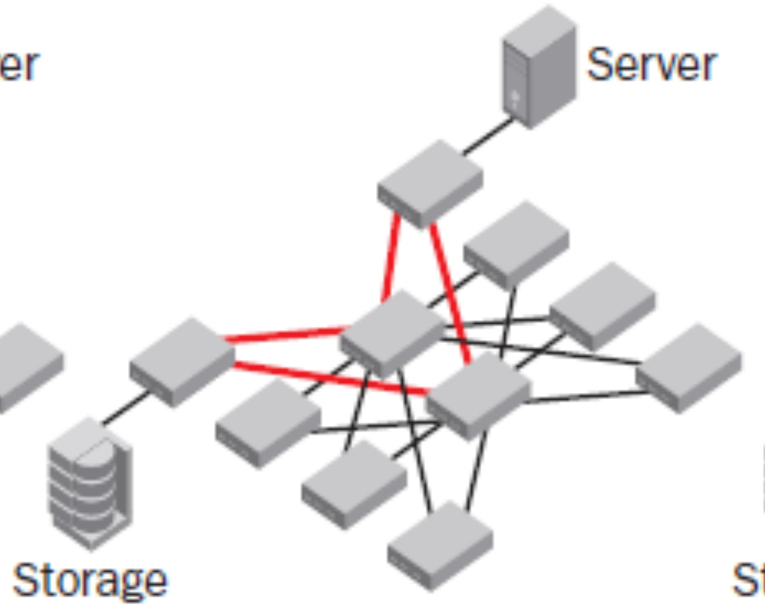
Scenario A



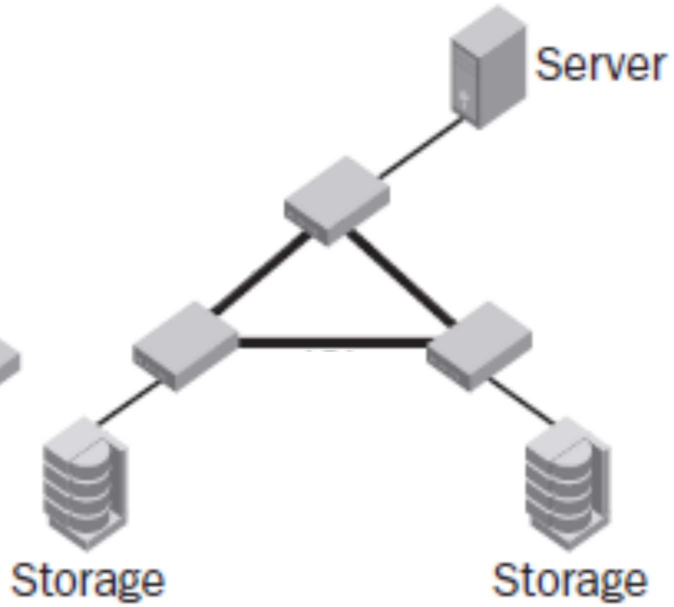
Scenario B
Edge-Core



Scenario C
Edge-Core-Edge

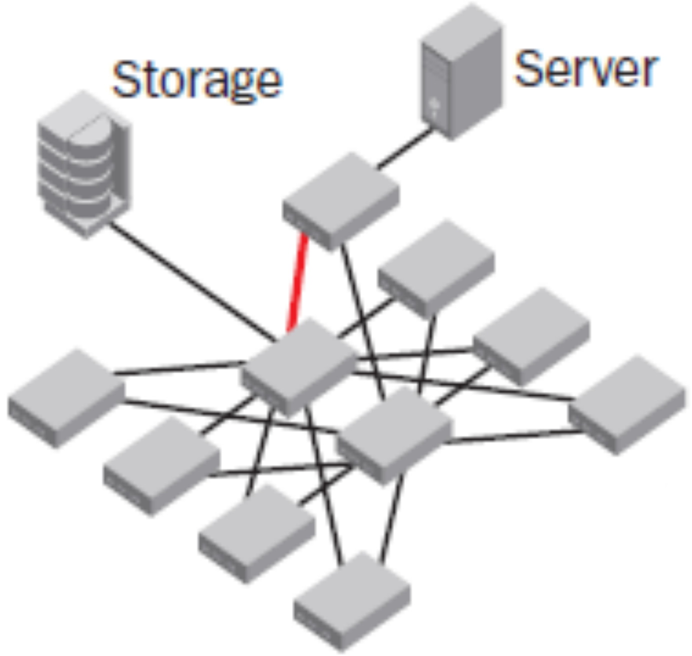


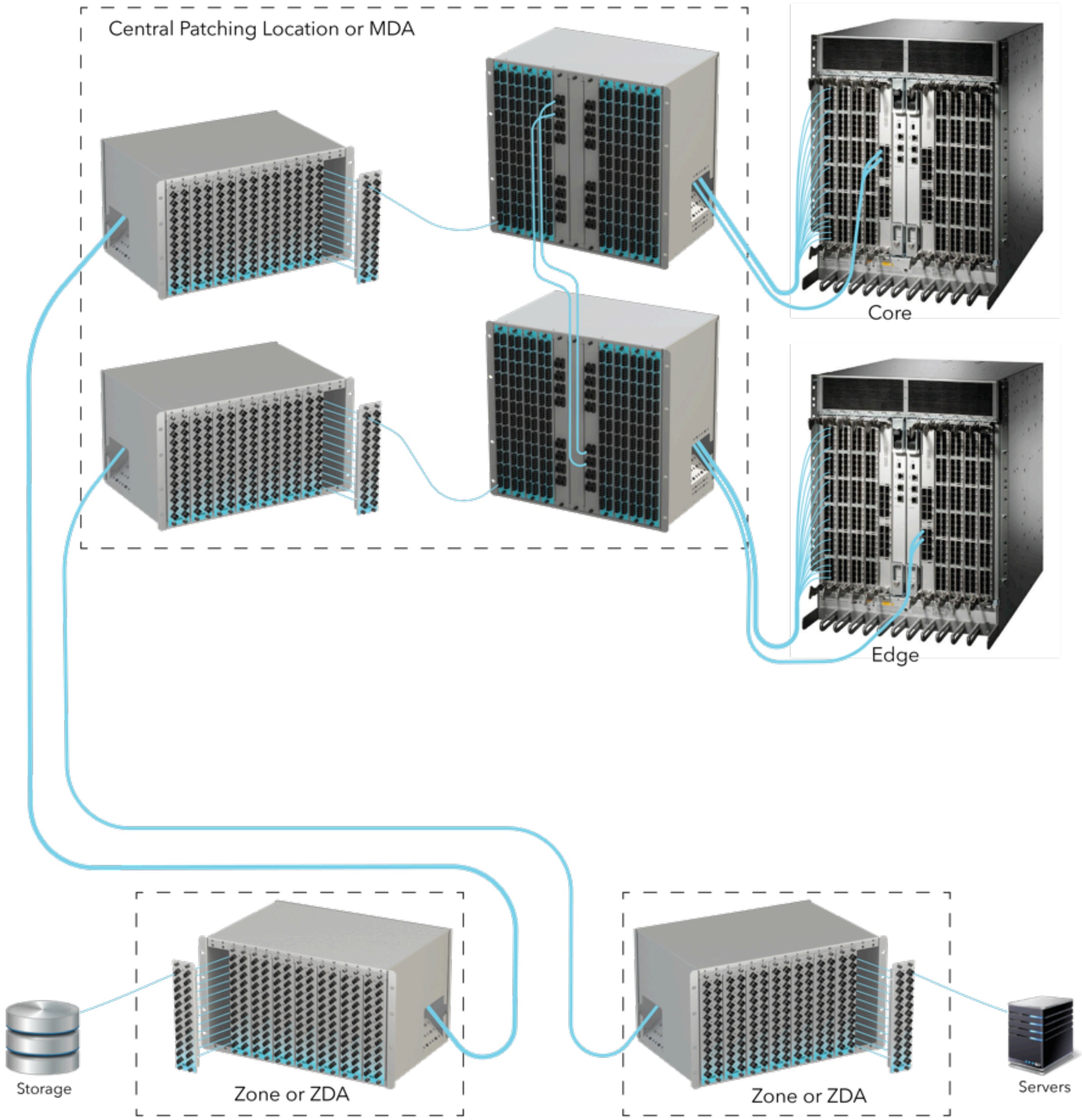
Scenario D
Full-Mesh



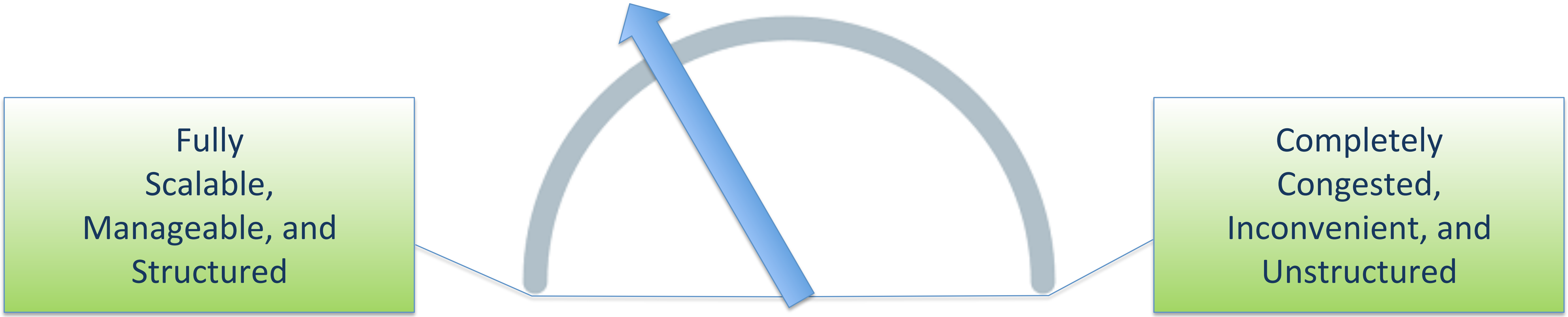
Fibre Channel SAN Cabling Topologies

A **physical cabling topology** can look very different than a **logical network topology**.





Fibre Channel SAN Cabling Methodology



Every Data Center’s cabling infrastructure is on a spectrum between a fully scalable, manageable and structured methodology and a completely congested, inconvenient and unstructured methodology.

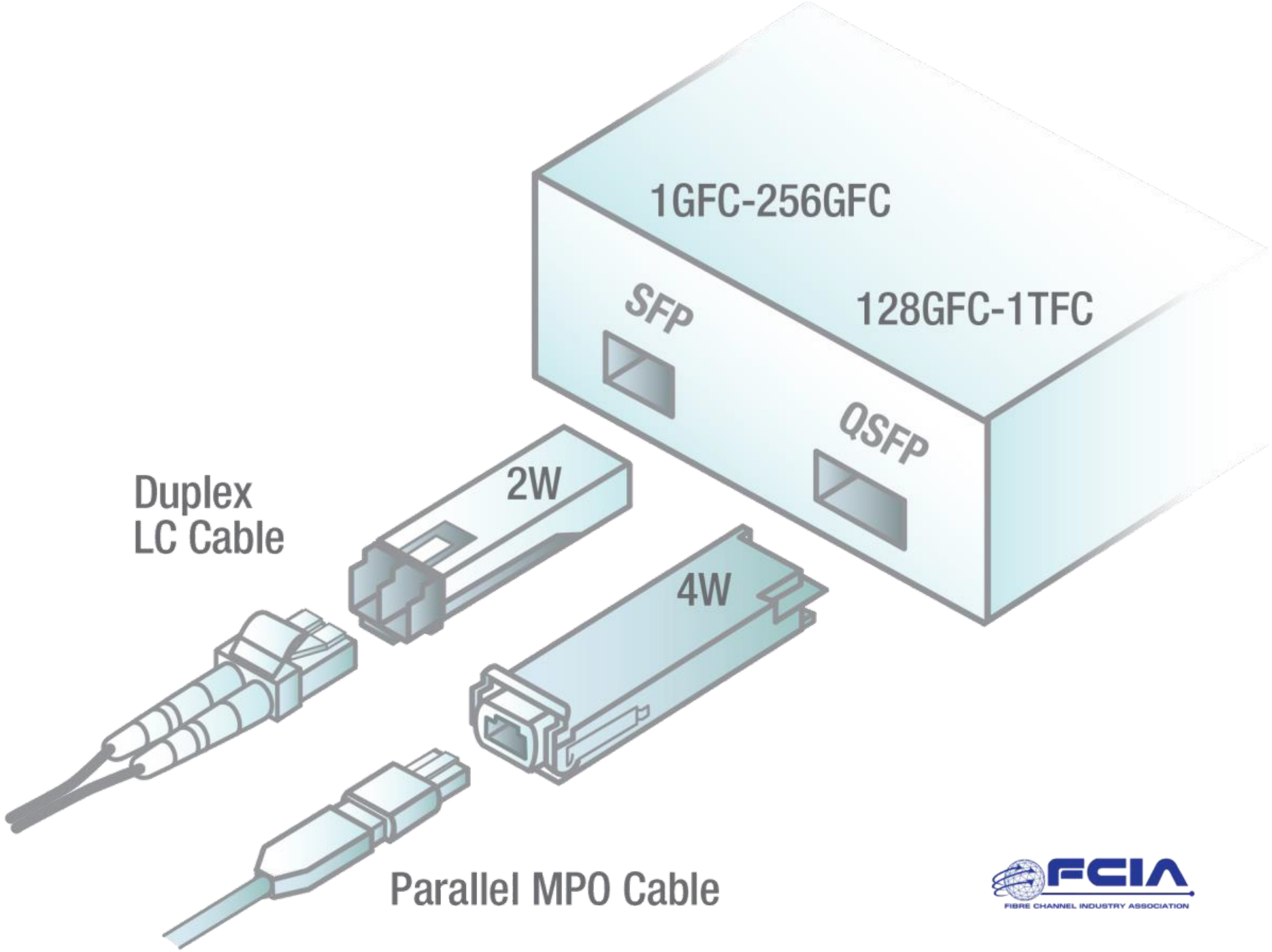
What are the Common Cabling Components of Fibre Channel?

Common Components of FC Cabling

Intra-Data Center Links
- Multi-Mode Fiber
- Twinax cables

Inter-Data Center and Mainframe Links
- Single Mode Fiber

FCIA webcast Long Distance FC
https://www.brighttalk.com/webcast/14967/277327

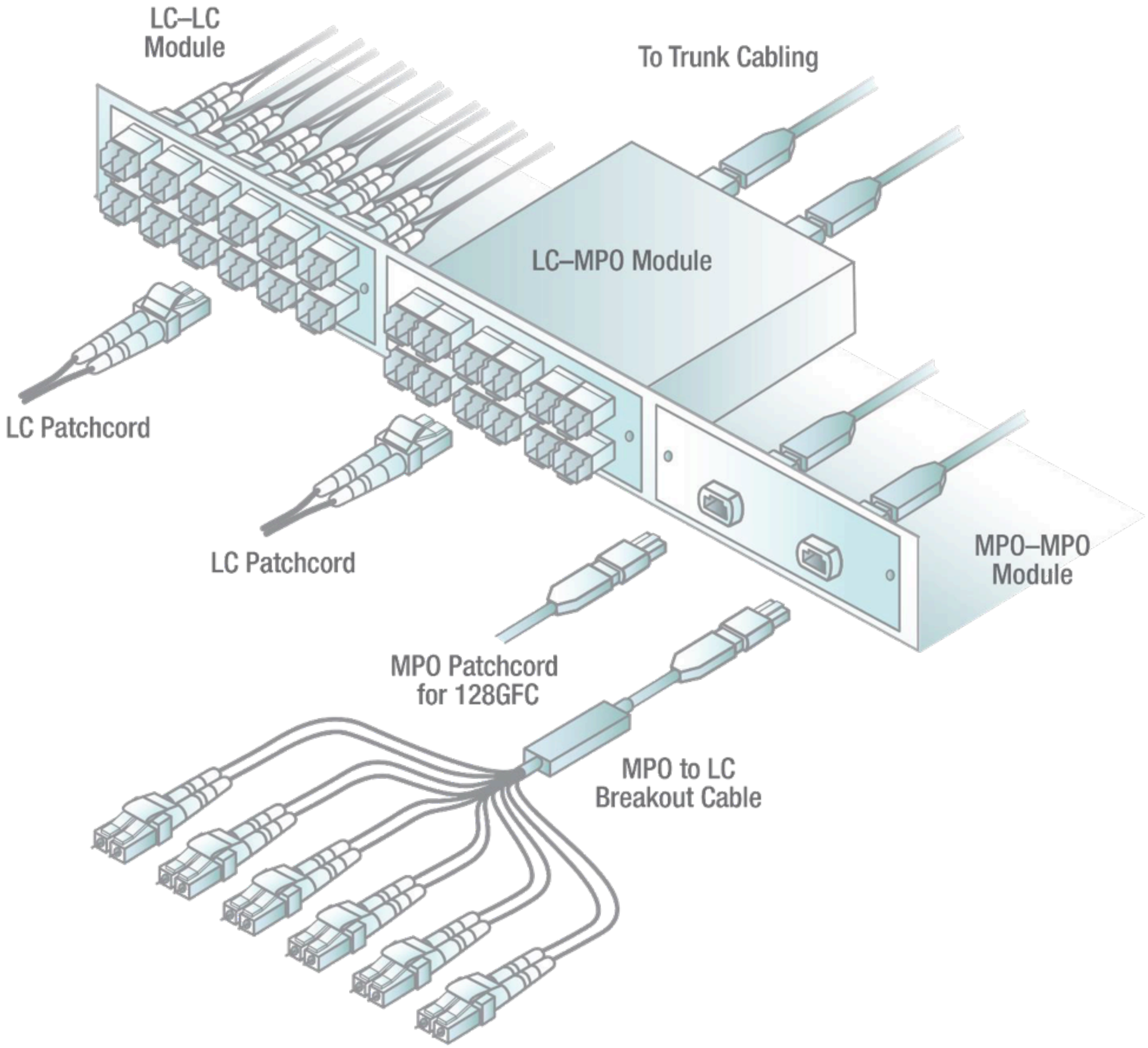


What is Structured Cabling, and Why is it Important?

What is Structured Cabling?

Structured connectivity in Fibre Channel environments allows for rapid connection and cabling management of switches to servers and storage and enables data centers to plan for evolution and growth of IT infrastructure.

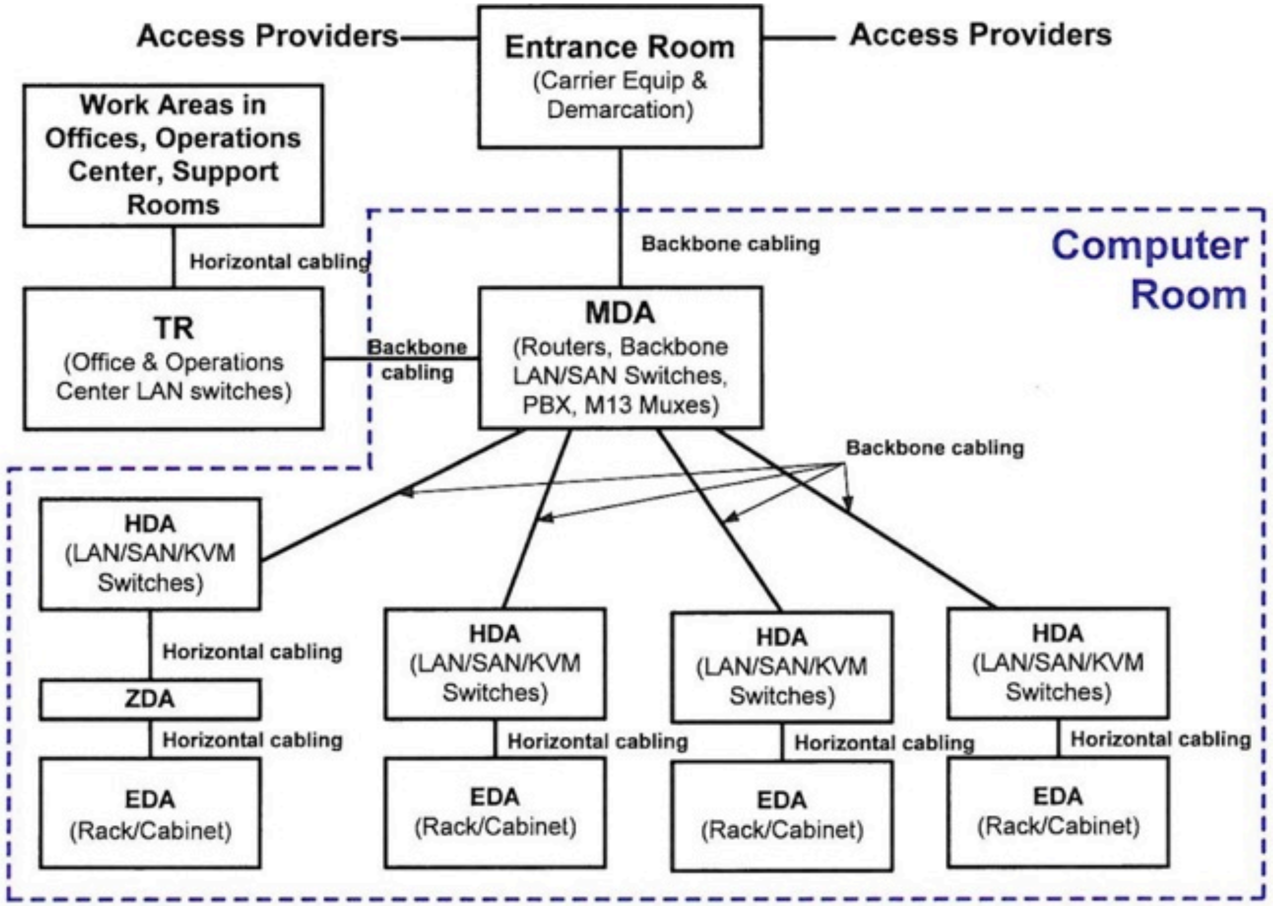
Structured cabling consists of a number of standardized smaller elements (hence structured) called subsystems.



We Have Standards

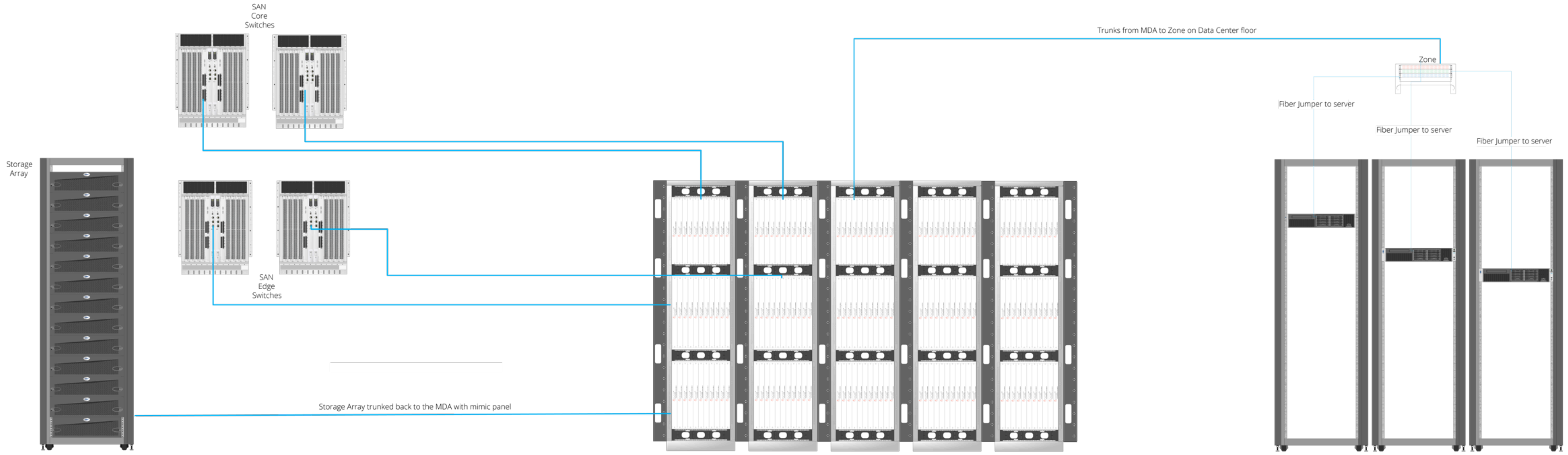
Network cabling standards are used internationally and are published by ISO/IEC, CENELEC and the Telecommunications Industry Association (TIA).

In the United States, the ANSI/ TIA-568-D and ANSI/TIA-942-B standards help to ensure a proper cabling installation.



Why is Structured Cabling Necessary?

With a correctly installed system your requirements of today and of tomorrow will be catered for and whatever hardware you choose to add will be supported.



Are There Copper Cables in Fibre Channel?

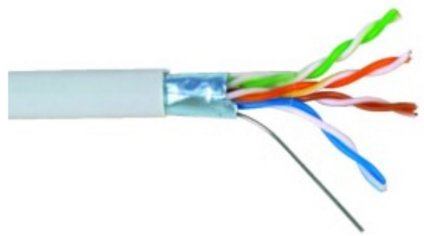
Yes. There is Copper Cables in FC.

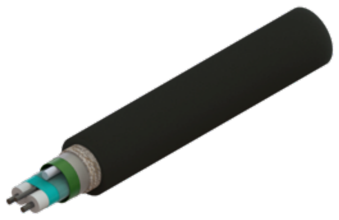
We **<u>are not</u>** talking about Twisted pair

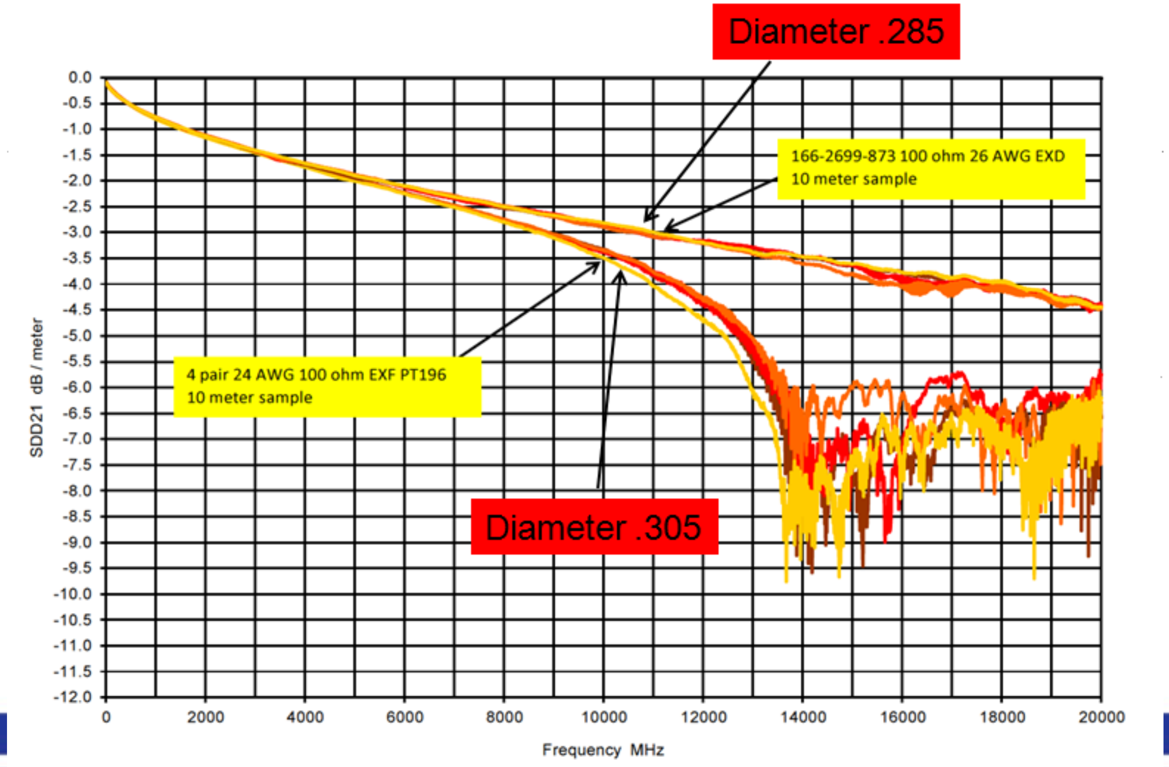
Fibre Channel copper cables are Twin-Axial type of cable, transmitting

Twin-Ax cable has much less insertion loss up to much higher frequencies

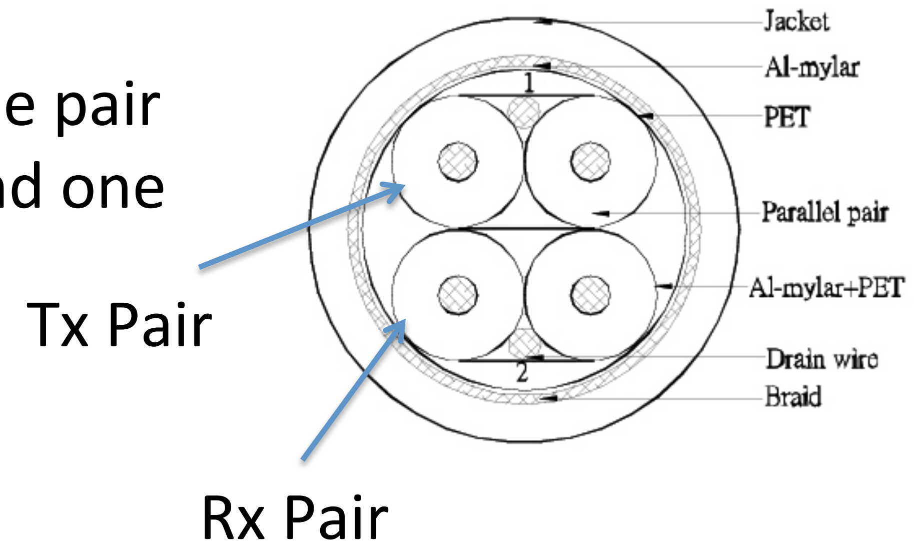
insertion loss: the ratio (expressed in dB) of incident power at one port to transmitted power at a different port, when a component or assembly with defined ports is introduced in to a link or system. May refer to optical power or to electrical power in a specified frequency range..



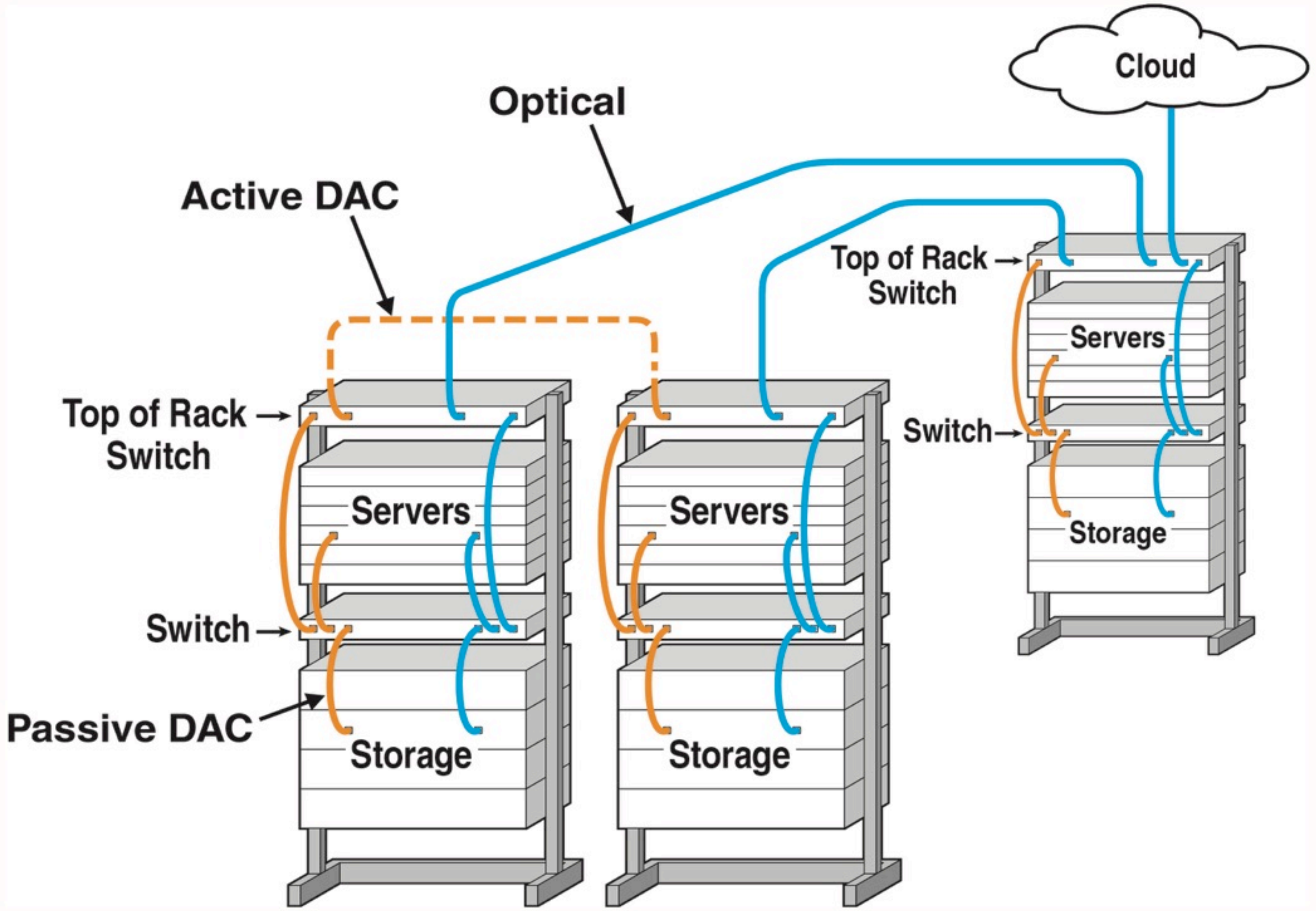




FC employs Differential signaling, so you have one pair for the transmit signal and one for the receive signal



Copper Cables in FC



- Optical Jumper cable >= 100m
- AOC, practical, up to 30m
- Active Copper cables
  - 4,8 Gb up to 10m
- Passive copper cable
  - up to 3 meters

What is Optical Fiber, and How Does It Work?

What is Fiber, and Why Do We Use It?

Fiber is ultimately just a “waveguide for light”.

- Basically: light that goes in one end, come out the other end.
- Most commonly made of glass/silica, but can also be plastic.

So why do we use fiber in the first place?

- Very low-cost to produce (silica is cheap).
- Extremely light (relative to copper), flexible material.
- Carries tremendous amount of information (20 Tbps+ today).
- Can easily carry large numbers of completely independent signals over the same fiber strand, without interference.
- Can carry signals thousands of kilometers without regeneration.
- Technology continues to radically improve what we can do with out existing fiber infrastructure, without digging or disruption.

A quick flashback to High School physics class:

Light propagating through a vacuum is (theoretically) the maximum speed at which anything in the universe can travel.

- That speed is 299,792,458 meters per second, otherwise written as “c”
- For doing shorthand math, you can round this up to 300,000 km/s.

But when light passes through material that **aren’t** a perfect vacuum, it actually propagates much slower that this.

- The speed of light in any particular material is expressed as a ratio relative to “c”, known as that material’s “refractive index”.
- Example: Water has a refractive index of “1.33”, or 1.33x slower than “c”.

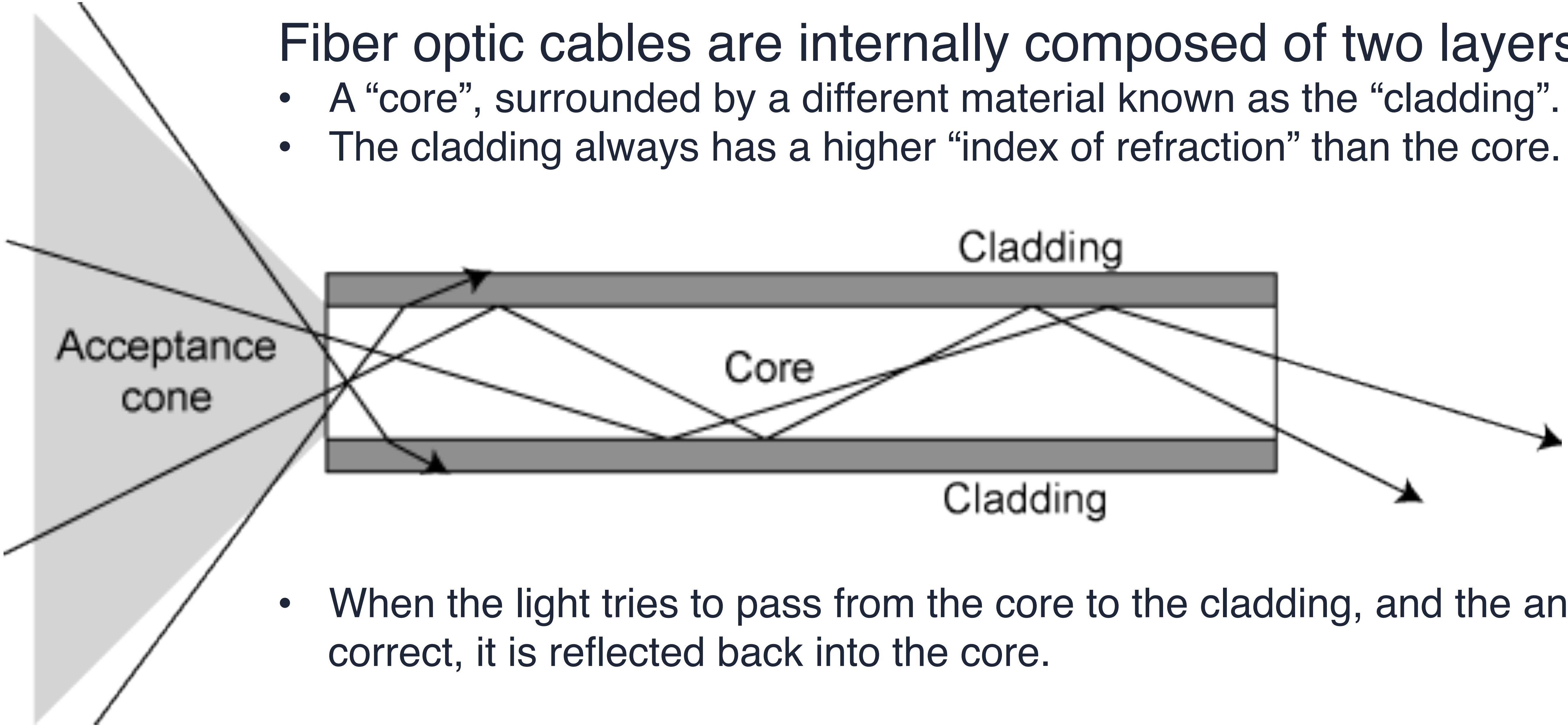
And when light tries to pass from one medium to another with a different index of refraction, a reflection can occur instead.

- This is why you will see a reflection when you look up from under water.

Fiber works by "Total Internal Reflection"

Fiber optic cables are internally composed of two layers.

- A "core", surrounded by a different material known as the "cladding".
- The cladding always has a higher "index of refraction" than the core.



- When the light tries to pass from the core to the cladding, and the angle is correct, it is reflected back into the core.

How Signal Power is Lost in Optical Fiber

Attenuation

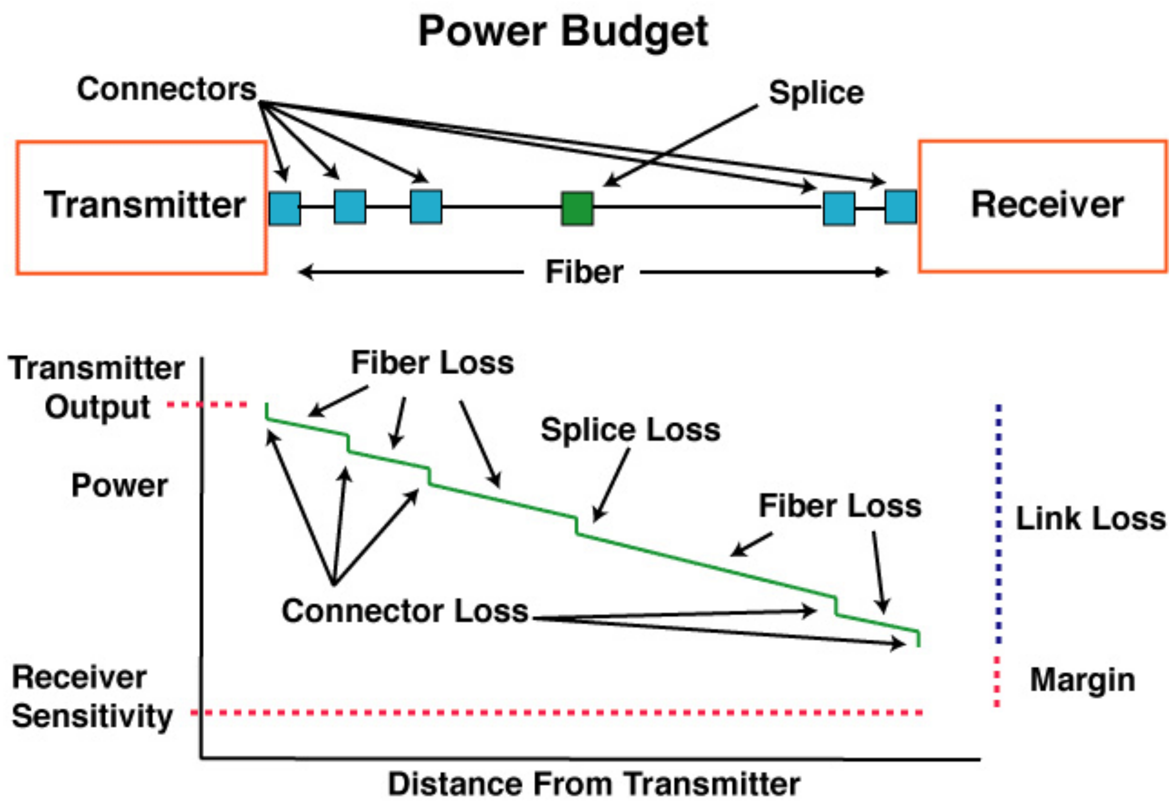
- The attenuation, or transmission loss, defines how much light is reduced with respect to distance travelled.

Reflectance

- The reflectance, or return loss, defines how much light is reflected back into the transmitter.

Connector Loss

- Defines how much light is reduced through a connection.



How Do We Actually Use The Fiber?

The vast majority of deployed fiber optic systems operate as “duplex”, or as a fiber pair.

- One strand is used to transmit a signal, the other to receive one.
- This results in the simplest and cheapest optical components.
- And usually holds true whenever the fiber is relatively cheap.

But fiber is perfectly capable of carrying many signals, in both directions, over a single strand.

- It just requires more expensive optical components to do so.
- And is typically reserved for systems where the fiber in question is relatively expensive.
- As with most things in business, cost is the deciding factor behind the vast majority of the technology choices we make.

What Do We Actually Send Over Fiber?

Our digital signals must be encoded into analog pulses of light

- The simplest (and cheapest) method is known as “IMDD”.
  - Which stands for ”Intensity Modulation with Direct Detection”.
  - Typically encoded as “NRZ”, or “Non-Return to Zero”.
  - Which is really just a fancy way of saying “bright for a 1, dim for a 0”.
- This modulation (called “baud”) can happen billions of times/sec.
  - The receiving end “sees” these flashes, and turns it back into 1s and 0s.
  - This technique was used for essentially all optical signals up to 16Gbps FC.
- Beyond 25GBaud, this technique gets increasing hard to scale.

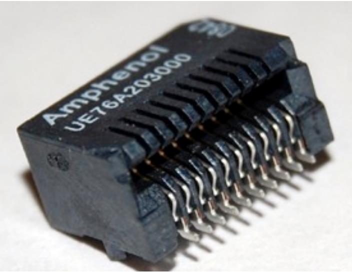
“Better than NRZ” systems are becoming more pervasive.

- PAM4 (Pulse Amplitude Modulation) QSFP28 optics delivering are starting to ship today, etc.

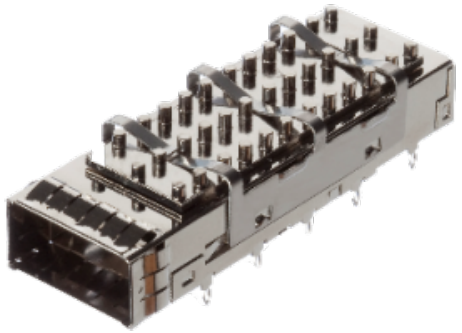
Can I Use the Same Connectors When the Fibre Channel Speed Increases?

Can we use the same connectors?

- Yes!, the same forma factor has been used since 1GFC
  - At every speed increase there have been tweaks to the certain area of the connector and plug but same form factor.
  - Single lane
- QSFP was adopted for the 128GFC, 4 lanes of 32Gb
  - 4 lanes



SFP



QSFP

What is the Difference Between Multi-Mode and Single Mode Fiber Types?

Multi-Mode Fiber (MMF)

Specifically designed for use with typically “cheaper” light sources.

- Has an extremely wide core, allowing the use of less precisely focused, aimed, and calibrated light sources.
- But this comes at the expense of long-distance reach.
  - Fiber is so named because it allows multiple ”modes” of light to propagate.
  - “Modal dispersions” typically limit distances to “tens to hundreds” of meters.

Types of Multi-Mode

- OM1/OM2: found with orange fiber jackets.
  - OM1 has a 62.5 micron (μm) core, OM2 has a 50μm core.
  - Originally designed for 100M/1310nm signals, starts to fail at 16G speeds.
- OM3/OM4 aka “laser optimized”: found with “aqua” fiber jackets.
  - Specifically designed for modern 850nm short reach laser sources.
  - Supports 16G signals at much longer distances (300m, vs 26m on OM1, approx.).
  - Required for 32G/128G signals (which are really both 32G signals), 100m.

Single Mode Fiber (SMF)

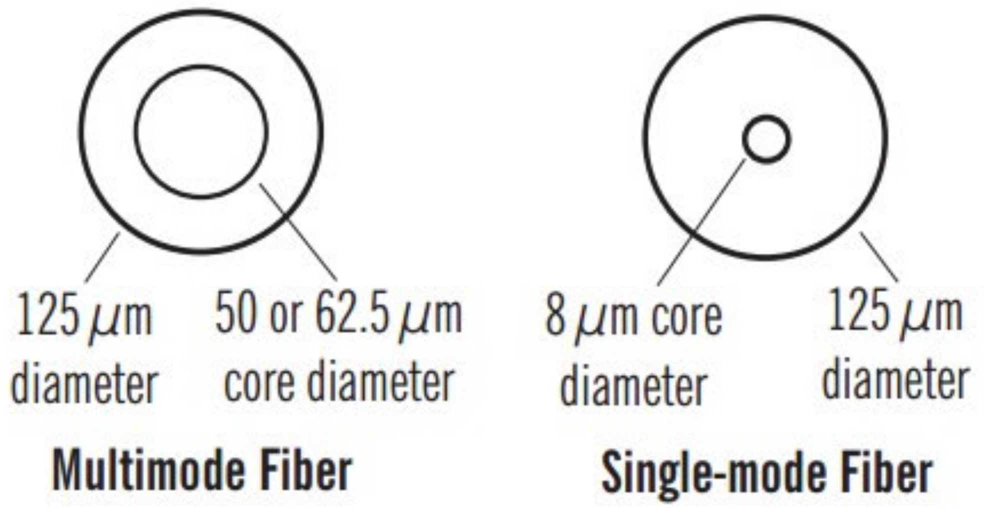
The fiber used for high bandwidths, and long distances.

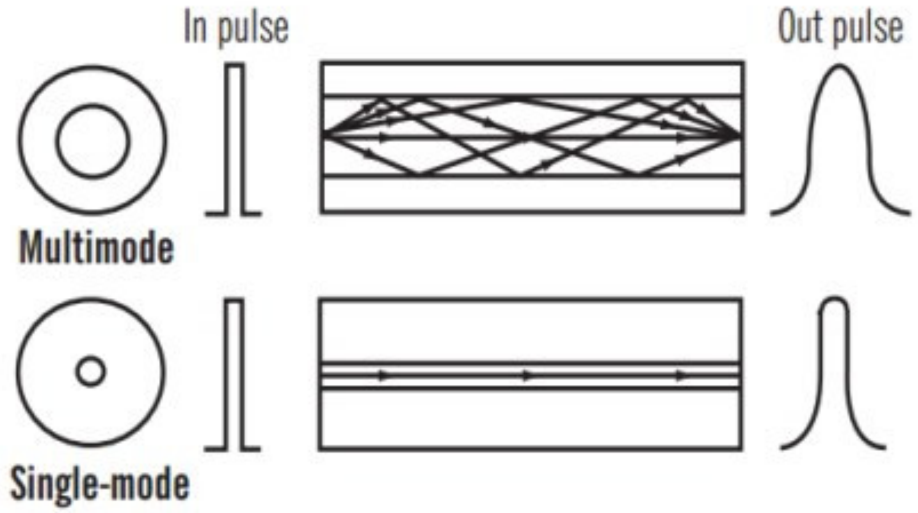
- Has a much smaller core size, between 8-10 microns (μm).
- No inherent distance limitations caused by modal dispersion
  - Can easily transmit a signal several thousand kilometers (with appropriate amplification), without requiring regeneration.
  - Typically supports distances of ~80km even without amplification.

SMF has an even broader array of types than MMF.

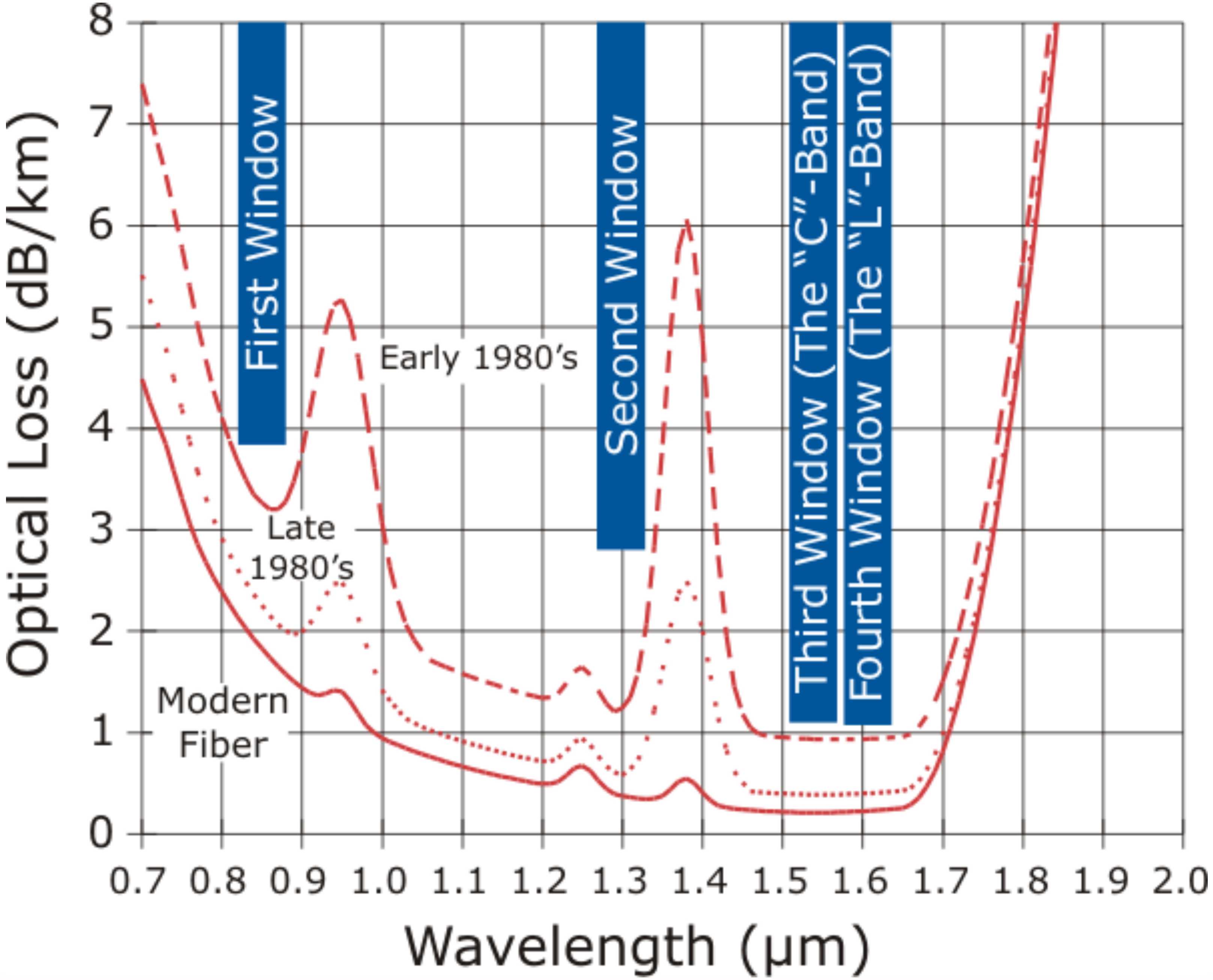
- OS1 ”tight buffered” for indoor use, OS2 “loose” for buried use.
- ”Classic” SMF can be called “SMF-28” (a Corning product name)
- But it also comes in many different formulations of Low Water Peak Fiber (LWPF), Dispersion Shifted Fiber (DSF), Non-Zero Dispersion Shifted Fiber, Bend Insensitive Fiber, etc, etc, etc.

Multi-Mode (MMF) and Single Mode Fiber (SMF)





Multi-Mode (MMF) and Single Mode Fiber (SMF)



Why is Bit Error Rate Important in Fibre Channel?

Why is BER Important?

- Measures the data transmission performance of your system
- You want your transmissions to be as lossless as possible
- One Decimal out of place can cause a lot of trouble.
  - $1000.00 vs. $100.00
- BER, Bit Error Rate / Bit Error Ratio
  - Bit Error Rate = number of errors during a certain time unit
- Bit Error Ratio = FC definition, “is the number of bits output

  from a receiver that differ from the correct transmitted bits, divided by the number of transmitted bits”.
  - A bit error is any received bit that has been distorted in some way.

BER

- FC requires a raw BER of less than or equal to 10^{-12} up to 16GFC
- 32GFC calls for a raw BER of less than or equal to 10^{-6} because at 32GFC, 256B/257B encoding which includes Forward Error Correction (FEC). Combined this give a BER of better than 10^{-12}
- When using 10GBASE-T, FCoE requires Cat6a or Cat7 to meet 10^{-12} requirements

In Conclusion

- The reliability of Fibre Channel allows for many cabling options going from 1 meter to 10+ kilometers
- The design goal should be to ensure simplicity for easier management, future expansion, and serviceability
- Structure cabling can help meet that goal
- Fibre Channel merges the performance and reliability of local storage with the connectivity and distance of networks

Q&A

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Register at:

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