Data Center ITMAX

Application Guide

Connectivity in Data Center Environments

FURUKAWA ELECTRIC GROUP

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Furukawa Data Center

From design to support.
From infrastructure to cabling.
From installation to management.

Watch the video of the solution:

Network infrastructure solutions for various applications.

Enterprise

Edge

Hyperscale

Furukawa solution is already in operation in several Brazilian corporations.

BANKS
AIRPORTS
PUBLIC BUILDINGS
HOSTING/COLOCATION
INDUSTRIES
OPERATORS
TELECOM

Why Furukawa?

In recent years, there has been an unprecedented increase in information traffic, which is demanding not only from transmission networks, but also from storage, response and management capacity in data centers. This new reality requires high training of professionals working in this segment, generating new careers and areas of knowledge, in addition to infrastructure prepared for data protection and maintenance.

Data Centers are complex structures that demand solutions from multiple vendors and services from multiple sources, requiring management skills and clarity of objectives. The only way to minimize risks from planning – through operation, eventual maintenance and corrections – is based on the purpose of Data Center.

However, some features are vital for any data center, such as the need for high availability, based on redundancy, energy and operational efficiency, and ease of maneuvering. This guide summarizes best practices in each of these pillars.

High Availability
Minimize risks of *downtime*

High Density and Operational
Lower energy cost

Performance
Performance and high transmission rates

Management
BIM Architecture with management *software*

Future-proof
Modular solutions that enable growth

Support and Services
Project monitoring and 25 Years Extended Warranty


SERVER SYSTEM 5000

My challenge in Data Center design is to integrate solutions and services from multiple vendors.
I must think long term to minimize the risks of planning, operation and future maintenance and to optimize investment.
All my thinking must be purpose-oriented.

Project Engineer

Specifying a Data Center

Purpose Orientation

Long Term Planning

Integration of Multiple Vendors

Investment Optimization

1 Concepts, Models and Standards for Data Centers

In any organization, the **central element of the infrastructure is the Data Center** – the integrated set of components that allows the provision of high value-added services, performing the processing and storage of data on a large scale and high availability. The Data Center must be, above all, highly reliable.

In this chapter, you will learn more about the indispensable components to build a data center and the Furukawa options that meet these needs.

DID YOU KNOW?

*There are several models of Data Center: **Enterprise** (private corporations and government agencies), **Internet** (service providers and telephone operators), **Colocation** (allocation of physical space for contractors), **Hosting** (services to minimize investment in hardware and software) and **Hyperscale** (large content providers).*

Standards and Concepts

Standard bodies such as ANSI/TIA have created specific standards for this critical application environment. The most remarkable ones are:

- **ANSI/TIA-942-B** – Telecommunications Infrastructure Standard for Data Centers.
- **ANSI/BICSI 002-2019** – Data Center Design and Implementation Best Practices.
- **EN 50600-1** – Information Technology – Data Center Facilities and Infrastructures – Part 1: General Concepts.
- **ABNT NBR-14565:2013** – Structured Cabling for Commercial Buildings and Data Center (In the near future: ABNT NBR 16665 – Structured Cabling for Data Centers).

STRUCTURED CABLING:

- **ISO/IEC 11801-5:2017** - Information Technology – Generic Cabling for Client Premises – Part 5: Data Center (previous ISO/IEC 24764).
- **EN 50173-5:2018** – Information Technology – Generic Cabling Systems – Part 5: Data Center Spaces.
- **EN 50600-2-4:2015** – Information Technology – Data Center Facilities and Infrastructures – Part 2 - 4: Telecommunications Cabling Infrastructure.

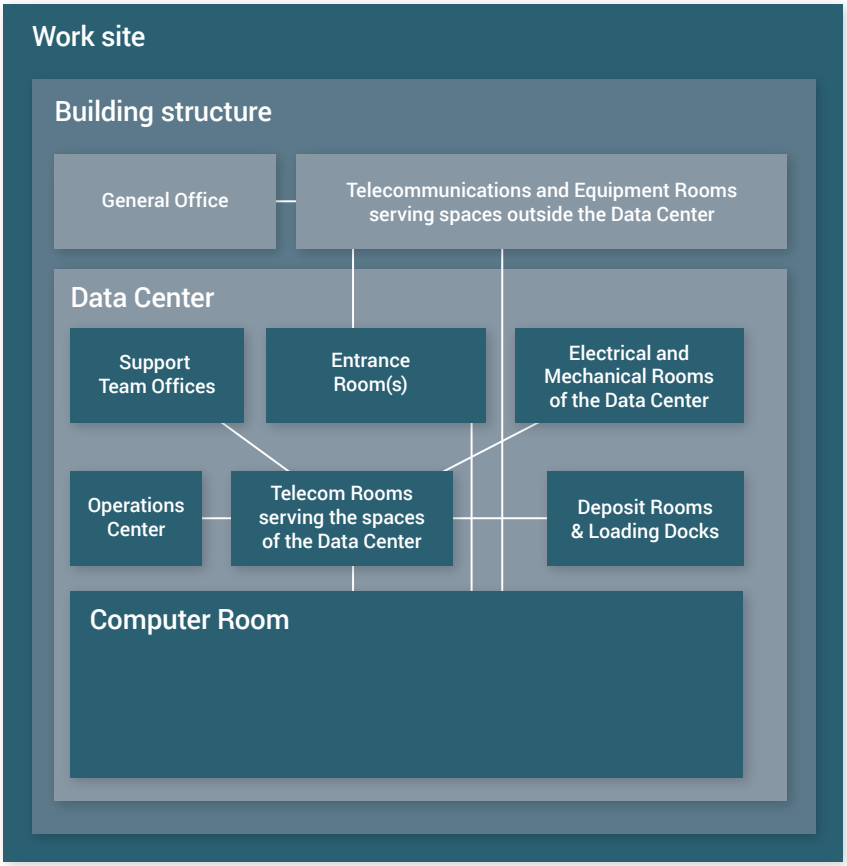
THE ANSI/TIA-942-B STANDARD

Specifies minimum requirements of telecommunications infrastructure for data center and computer rooms, including single-tenant or multi-tenant corporate data centers. The topologies specified in this document apply to data centers of any size. Additionally, it presents recommendations for infrastructure classification regarding redundancy and its availability, topologies, distances, cabling, requirements for physical construction, identification and administration.

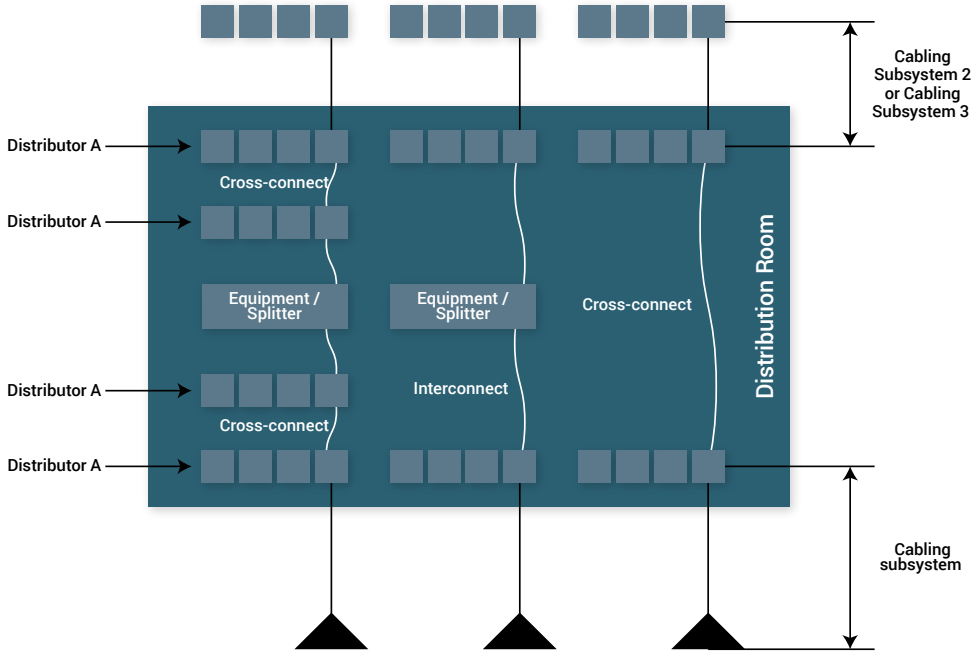
The major modifications in ANSI/TIA-942-B from ANSI/TIA-942-A include:

- CAT.8 cabling added, with CAT.6A cabling or higher recommended.
- Recommended maximum cable lengths for direct attach cabling in EDAs has been reduced from 10 m (33 ft) to 7 m (23 ft). Additional guidance added that direct attach cabling between rows is not recommended.
- Added recommendation to consider preconnectorized cabling to reduce installation time and improve consistency and quality of connections.
- Added recommendation to consider needs for proper labeling, cable routing, cable management, and ability to insert and remove cords without disrupting existing or adjacent connections.
- Added OM5 as an allowed and recommended type of multimode fiber cable.
- ANSI/TIA-5684-D coaxial cables and “F” type connectors can be used.
- References to other standards, including temperature and humidity revisions and guidelines.

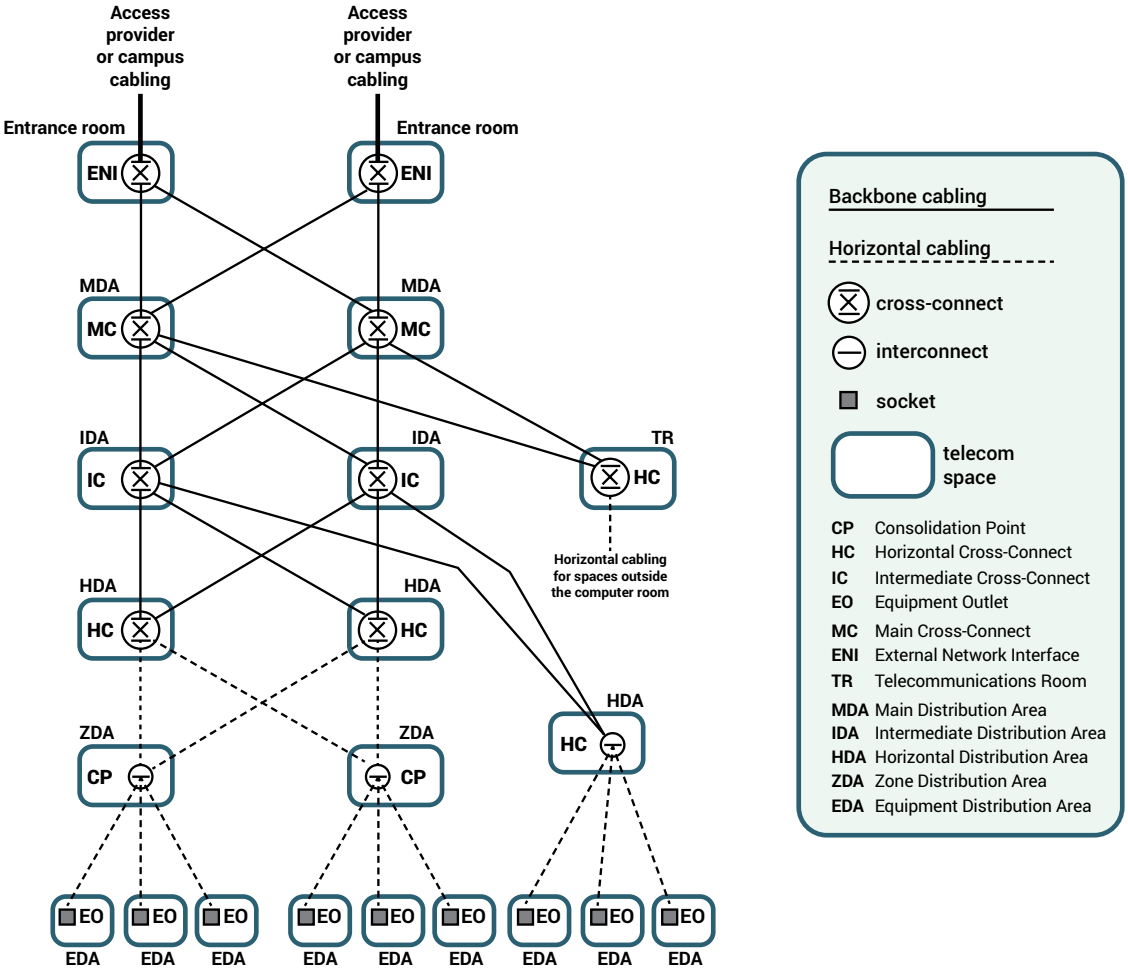
Minimal physical spaces, ways of connecting the telecommunications structure and the way in which the environments relate are in the scheme below:



Connections of telecommunications systems, recognized for structured cabling system of a Data Center are represented in the following image and can be interconnect or cross-connect:



All the functional elements that make up the cabling system of a Data Center are represented in the following diagram:

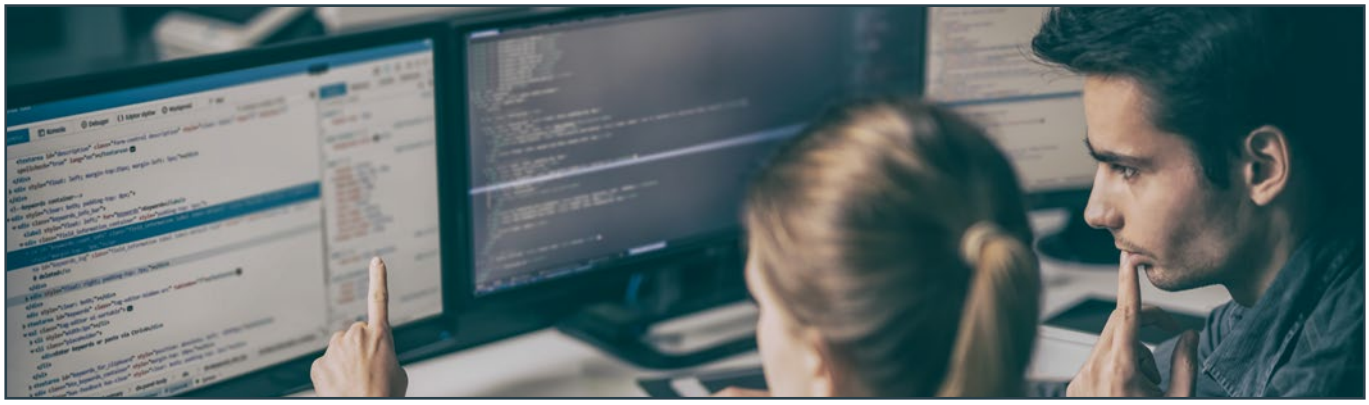


2 General Concepts and Requirements for Physical Infrastructure

Data Center is the environment that concentrates the company's information and is essential for driving the business and generating revenue.

Much more than servers and network equipment, it involves air conditioning systems, power supply, security and access control. In this context, the structured cabling system is a vital part of the infrastructure through which the data travels and business opportunities are created. As such, its correct scaling and specification must be guaranteed, in order to support current and future demands.

In this chapter, you will learn how a Data Center should be designed to ensure its organization, connectivity, availability and growth.



2.1. Main Spaces

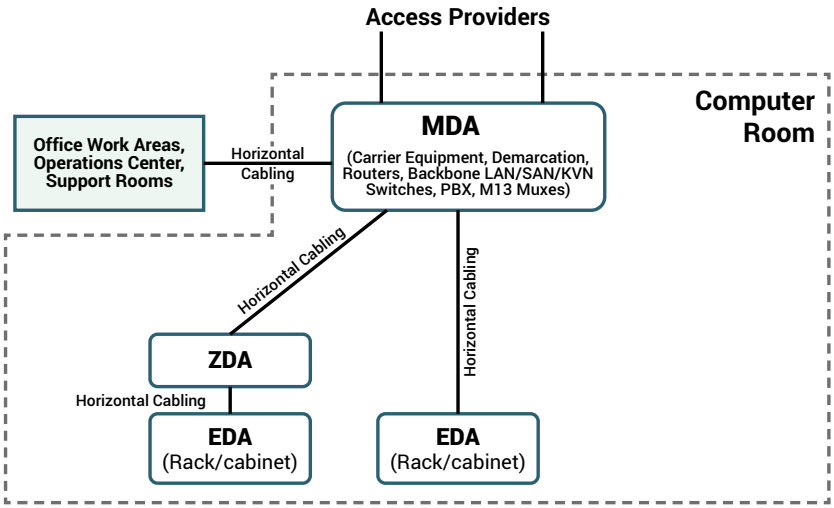
According to ANSI/TIA-942-B, the main spaces or areas of a Data Center are:

- **Entrance Room (ER):** The entrance room is an interconnection space between the structured cabling of the Data Center and the cabling coming from telecommunication operators.
- **Main Distribution Area (MDA):** Includes the cross-connect, which is the central distribution point of a structured cabling of a Data Center. It is a critical area, where its main maneuvers are performed.
- **Intermediate Distribution Area (IDA)**: Space intended for intermediate cross-connect, which is the secondary distribution point of a structured cabling in a data-hall. It is a critical area, as much as the MDA, where data-hall maneuvers are performed where it is installed.
- **Horizontal Distribution Area (HDA):** This is used to connect to equipment areas. It includes the horizontal cross-connect (HC) and intermediate equipment.
- **Zone Distribution Area (ZDA):** Optional horizontal cabling interconnection point. Positioned between HDA and EDA, it allows quick and frequent configuration, usually positioned under the raised floor. Adds flexibility to the Data Center.
- **Equipment Distribution Area (EDA):** Space for terminal equipment (Servers, Storage) and voice or data communication equipment (switches, exchanges).

2.2. Topologies

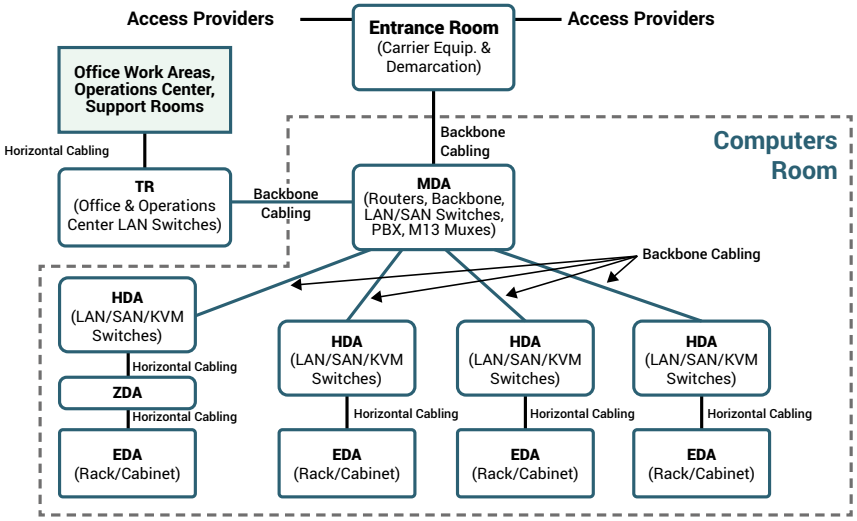
The standard presents three topologies according to the following schemes:

It has a single MDA that consolidates the main and horizontal cross-plug areas. The telecommunications room can also be consolidated in the MDA.



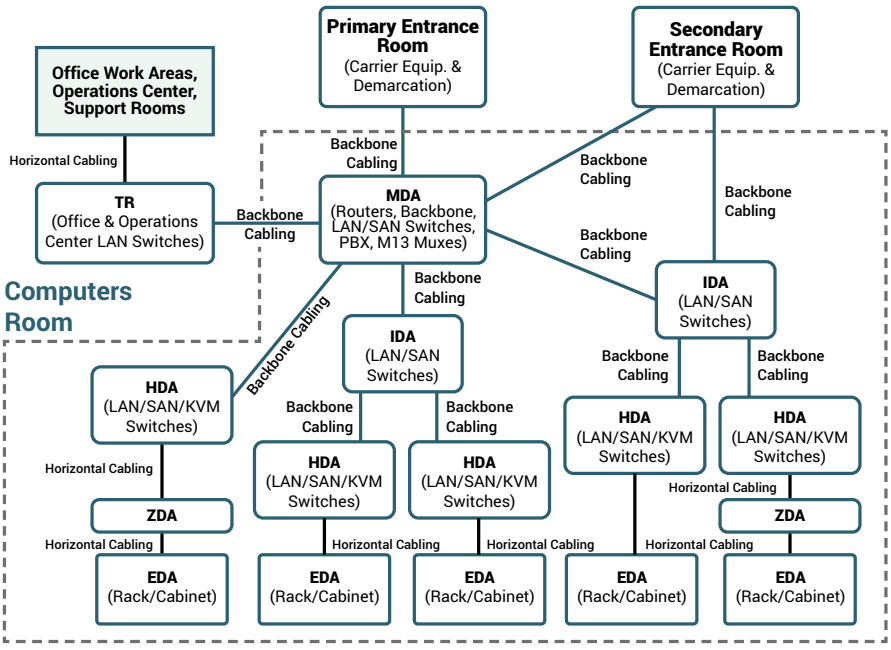
Reduced Topology

Includes a single entrance room, one or more telecommunication rooms, an MDA and multiple HDAs.



Basic Topology

Used in large data centers, which require areas of Intermediate Cross-connect (IDA) and multiple Telecommunications Rooms.



Distributed Topology

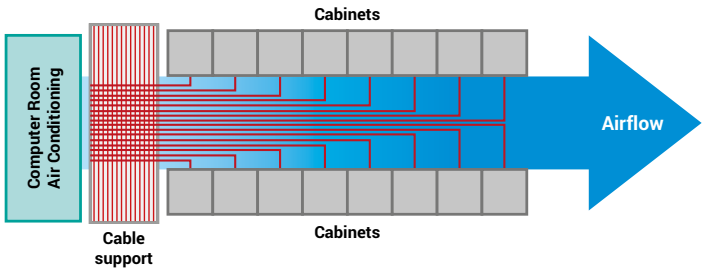
2.3. New Guidelines

DID YOU KNOW?

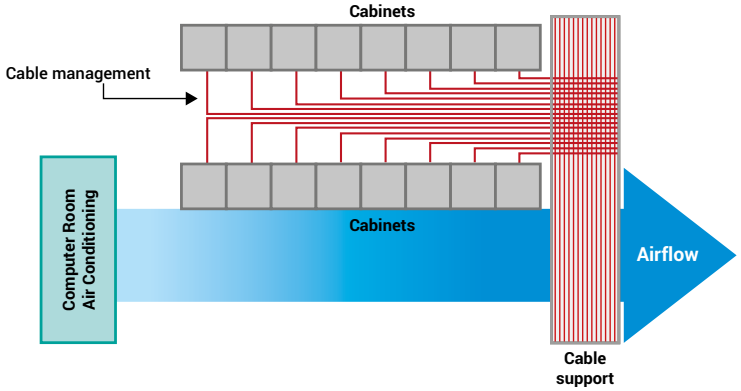
The revision of the ANSI/TIA-942-B Standard incorporated sustainability and energy efficiency trends, presenting new orientations to the engineering and architecture areas, allowing greater flexibility in projects.
The organization and installation of structured cabling under raised floors, and the layout of racks and cabinets in the server room, aim for greater efficiency, energy saving and climate control, as follows:

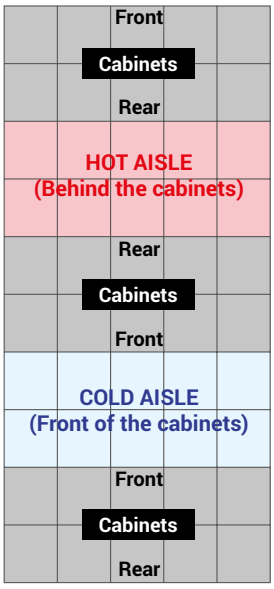
In this example, the recommendations regarding the position of channels and organization of structured cabling is clear.

Example of airflow and cable routing at maximum containment
(cables and cable support should not block the airflow to the cabinets)



Example of airflow and cable routing at minimum containment





Align the front or rear of the cabinets with the edges of the floor panels.

If they are uneven, the cold aisles should be the largest to possibly provide more cold air and provide more where the equipment is normally installed.

If telecommunication cables are installed under the floor, they should be under the hot aisle.

Power cables underfloor should be installed in cold aisle.

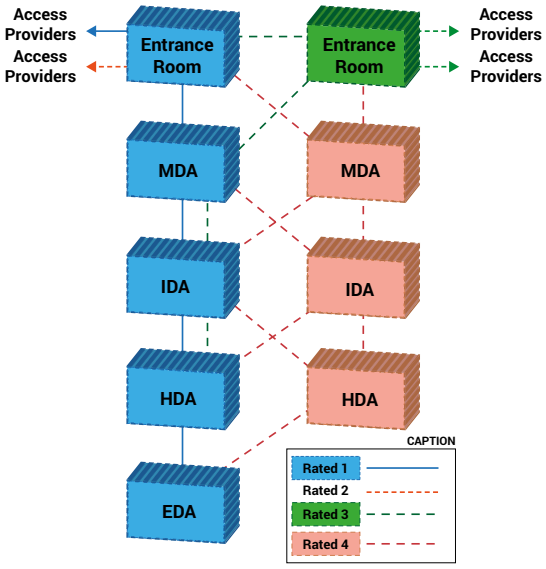
This drawing shows the layout of server room racks, positioned to form hot and cold air aisles, optimizing the use of power and cooling.

2.4. Redundancy Requirements

In order to reduce the downtime of the Data Center and your company's data, redundancy is a requirement also provided in standard. Annex F of the ANSI/TIA-942-B standard presents a series of applicable rules for classifying a Data Center, called Ratings. The classification considers four independent groups for the systems: Telecommunications, Electrical, Architecture and Mechanics. These ranges are related to the availability of the Data Center and may differ in each of these areas. The objective of this theme is the maintenance of the essential characteristics of the Data Center regarding its availability, reliability, security, resilience and redundancy necessary for its classification.

The ANSI / TIA-942-B standard defines the following classifications:

- Data Center Rated 1: Basic.
- Data Center Rated 2: Redundant components.
- Data Center Rated 3: Maintenance concurrent with the operation.
- Data Center Rated 4: Fault tolerant.

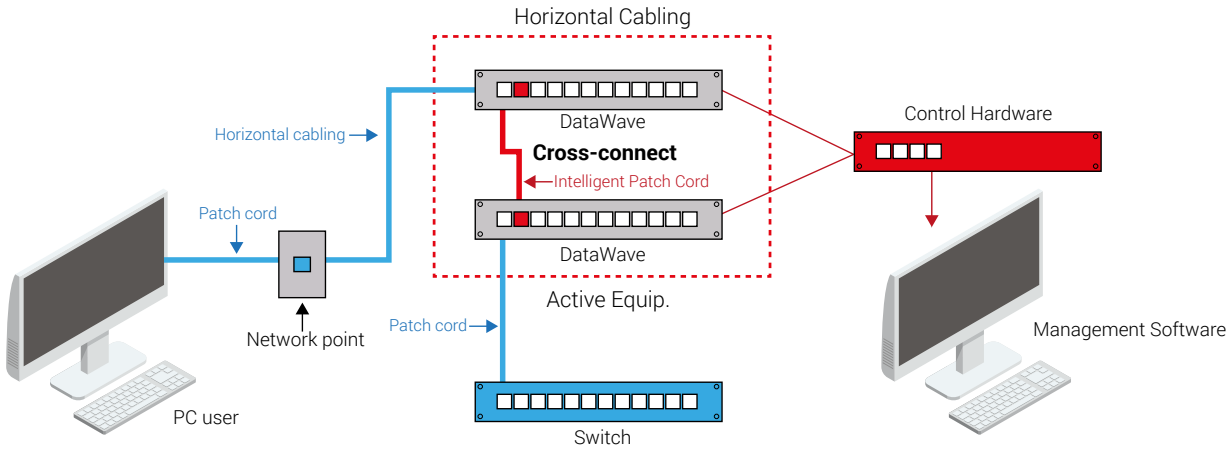


Source: ANSI/TIA-942-B

2.5. Availability Guarantee

In addition to the data center redundancy criteria, the topics below complement its availability assurance system, according to correlated standards in each topic (see chapters of the ANSI/TIA-942-B):

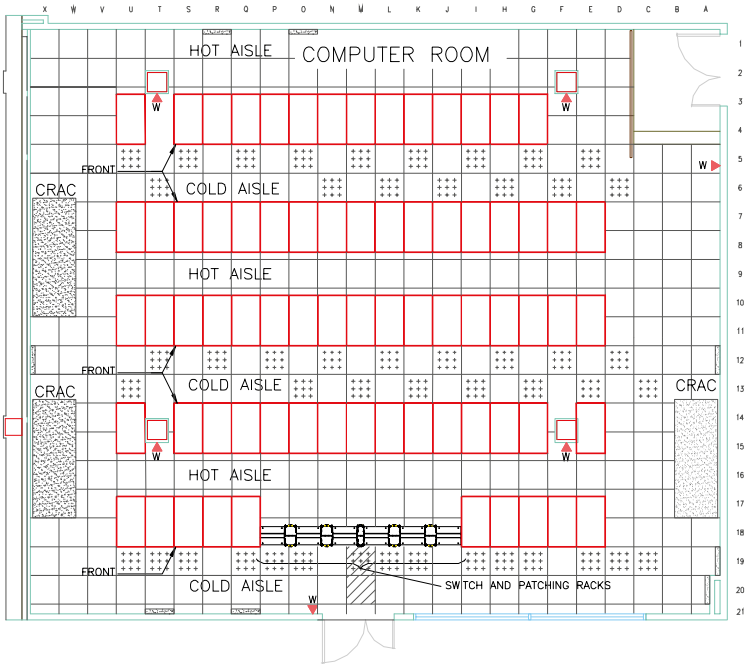
- **Wiring installation requirements**: the installation requirements of ANSI/TIA-568.0-D in addition to the other provisions of this standard, must be followed to comply with applicable codes and regulations.
- **Performance Requirements Cabling**: the transmission performance requirements of ANSI/TIA-568.2-D, ANSI/TIA-568.3-D and ANSI/TIA-568.4-D standards are the minimums to be satisfied.
- **Cabling for Wireless Access Points**: cabling must be provided to serve the wireless access network, according to ANSI/TIA TSB-162-A.
- **Wiring for Distributed Antenna Systems**: wiring for distributed antenna systems must follow the guidelines of ANSI/TIA TSB-5018.
- **PoE on Structured Copper Cabling**: follow ANSI/TIA TSB-184-A guidelines. For this application we already have UL444 certified cables with PoE W (IEEE 802.3bt, PoE Type 4, DC@100W) support for TVs and Laptops.
- **Grounding and Bonding**: grounding and bonding shall meet the requirements of ANSI/TIA-607-C.
- ***Firestopping***: protective barriers or fire sealing must comply with ANSI/TIA-569-D and local regulations.
- **Physical Security**: the physical security of the telecommunications infrastructure shall meet the requirements of ANSI/TIA-5017.



- **Administration**: telecommunications administration must meet the requirements of ANSI/TIA-606-C and also comply with the requirements of the AIM standards, namely:
  - **ANSI/TIA-5048**: *Automated Infrastructure Management (AIM) Systems.*
  - **ISO/IEC-18598**: *Automated Infrastructure Management (AIM) Systems – Requirements, data Exchange and Applications.*
  - These standards define how the AIM system should be, its functions, security, assembly, hardware and software, as well as its outputs and with which systems it should be integrated, e.g. field service systems, NOC, inventory, door provisioning, etc.

2.6. Data Centers examples according to its constructive dimensions. Annex G (informative) ANSI/TIA-942-B

Small Data Center



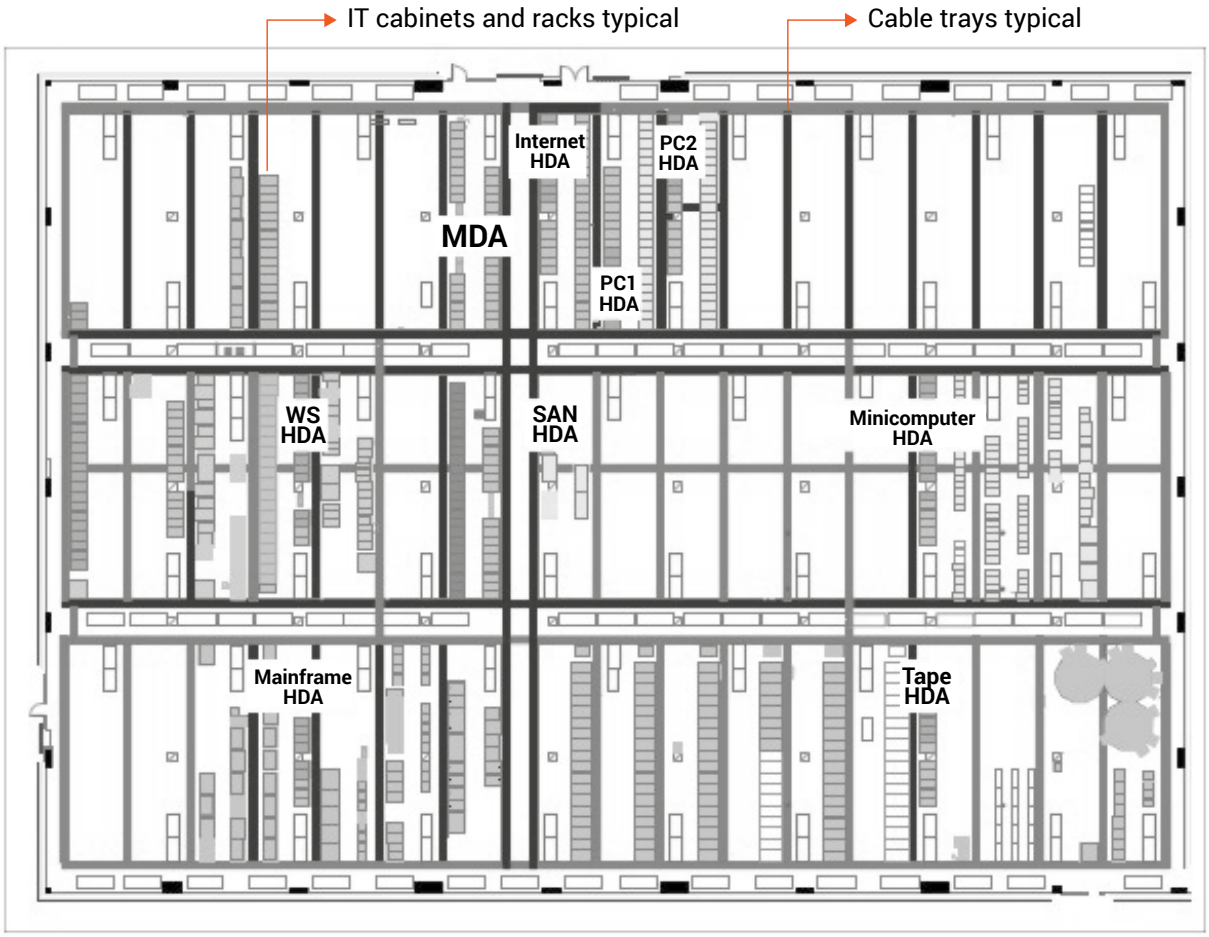
DC with 178 m², 73 EDAs and 1 MDA with 6 open racks with 2-posts.

DID YOU KNOW?

Data Centers can also have different classifications for different parts of their infrastructure, according to ANSI / TIA-942-B:

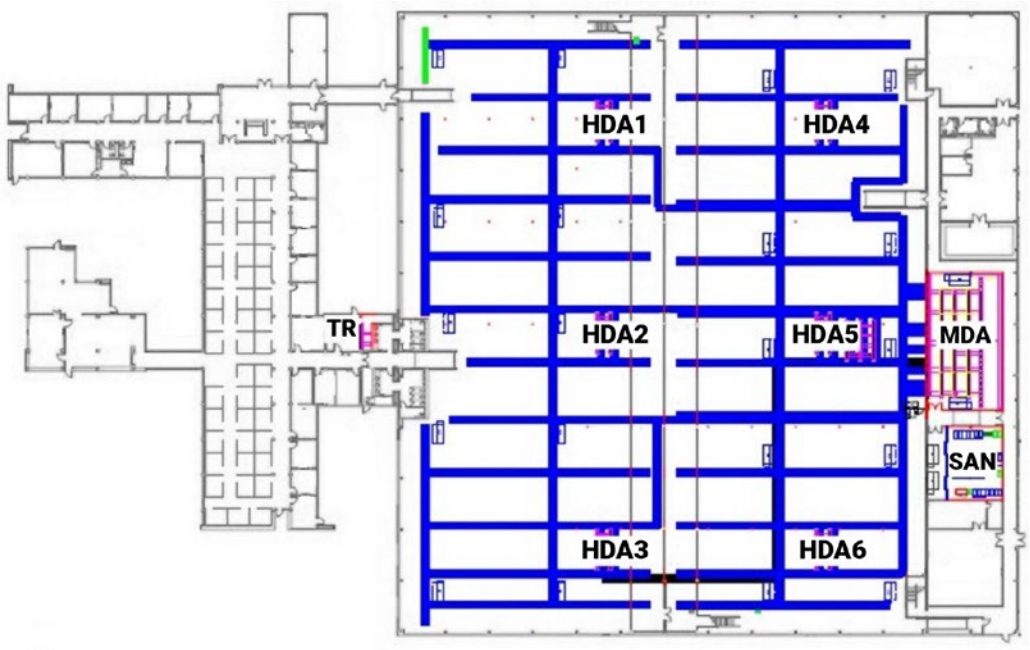
- *(T) - Telecommunications Part*
- *(E) - Electrical Part*
- *(A) - Architectural Part*
- *(M) - Mechanical Part*

Corporate Data Center



DC with 4140 m², many HDAs, recommended at speeds from 25 Gbps to 40 Gbps over CAT.8/OM4/SM. The first floor houses the basic infrastructure of the Data Center, electrical rooms, air conditioning, pump house, substation, generators, asset security, NOC, client room, unpacking, quarantine, reception, dock loading/unloading, telecom entrance room. The server room is exclusively isolated on the second floor.

Data Center Internet *(Hyperscale Data Centers)*



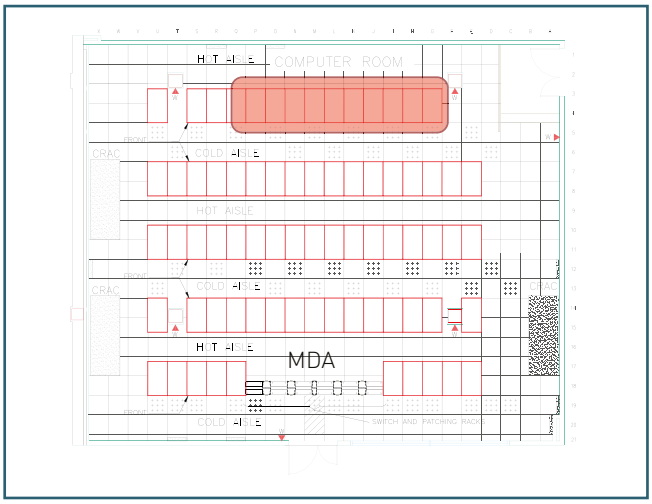
DC Hyperscale from 9500 m², and server room of 6400 m² with > ~4300 EDA.

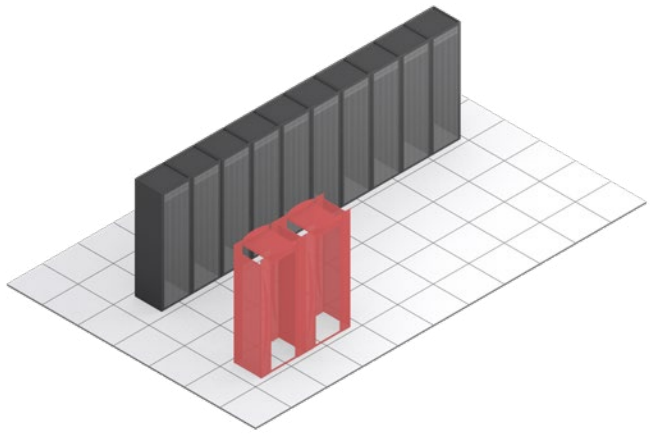
2.7. Connection Topologies between MDA-EDA

In order to connect all the devices in the MDA space to the devices in the EDA space, regardless of the size of the data center, various topologies can be applied - each with its own advantages and disadvantages. Next, it is possible to verify the details of the main topologies applied in the current data centers.

Centralized *Cross-connect*

In the centralized or directly connected topology, in the main area (MDA), there is a central network equipment, from where the connection is made to the servers that are in the EDA, as illustrated in the figures below:





ANSI/TIA-942-B

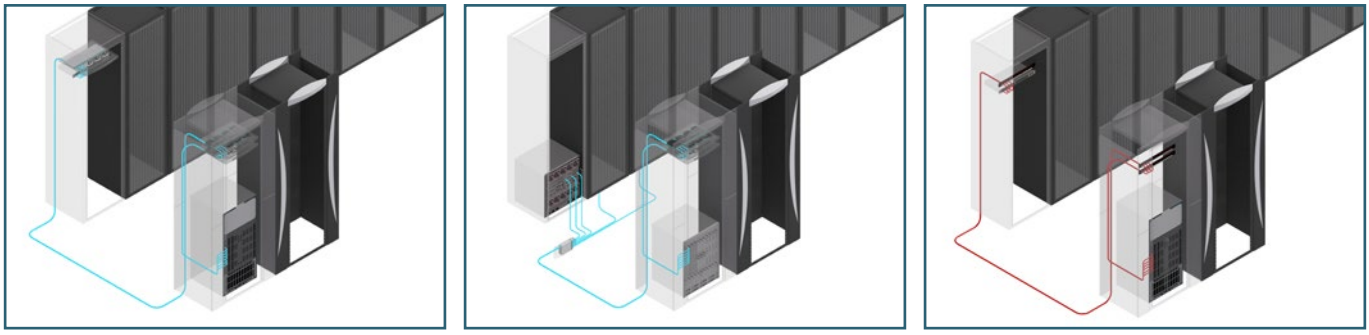
Analysis of the advantages and disadvantages of this topology:

ADVANTAGES

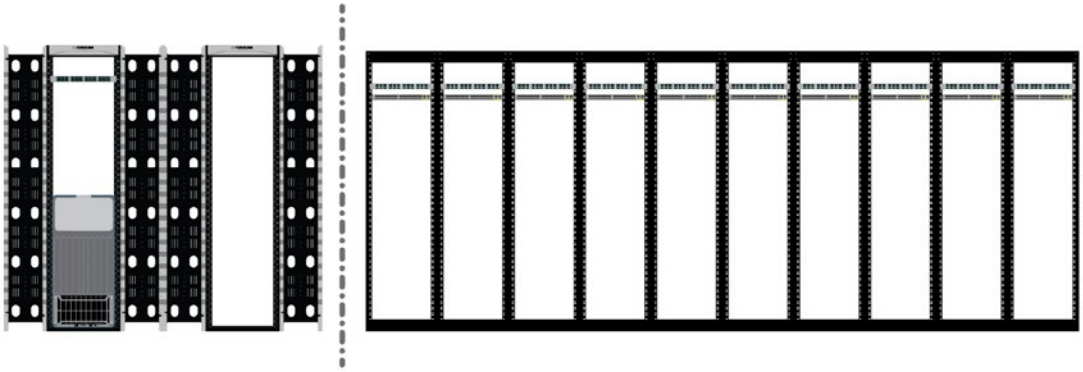
- Lower cost than distributed architectures.
- Simple to design, implement and maintain.
- Minimized bottleneck in the network.
- Good ports usage
- Simplified device management.
- Greater flexibility for inter-connect or cross-connect topologies.
- As all switches and other network equipment are centralized, the number of active equipment ports required for the project is minimized.
- Simplifies administration of cabling and active network equipment.
- Allows intelligent monitoring and administration systems (A.I.M.).
- Reduces the number of monitoring modules, administration modules and switch backbone ports: “more capacity in fewer boxes”.
- Reduces power consumption, redundancy and cooling needs.
- Reduces the length of equipment strings, even if there is mirroring of asset ports for cross-connect mounting.
- Easy to implement high availability schemes (redundancy).

DISADVANTAGES

- Too many cables in the MDA.
- Cables overlapped in the MDA and the main infrastructure.
- Difficulties in infrastructure design, due to the high density of structured optical and copper cabling.
- Not scalable.
- Increased number of cross-connects to manage and maintain
- More cabling links than other options (ToR or EoR/MoR).



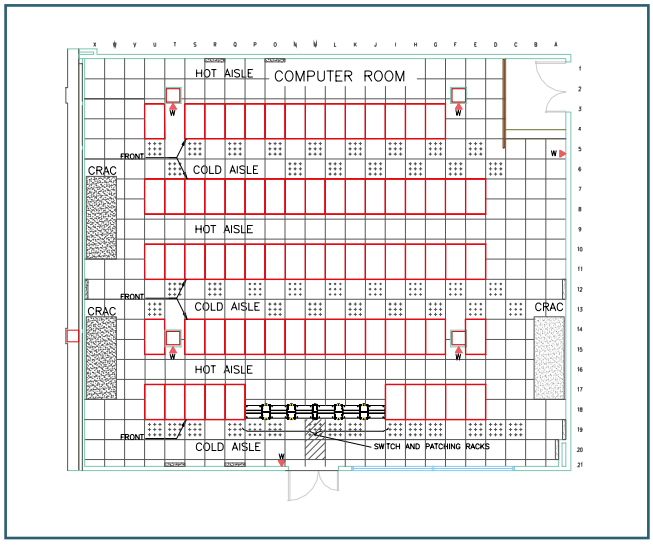
Demonstrated application of fiber and copper products to meet a centralized topology.



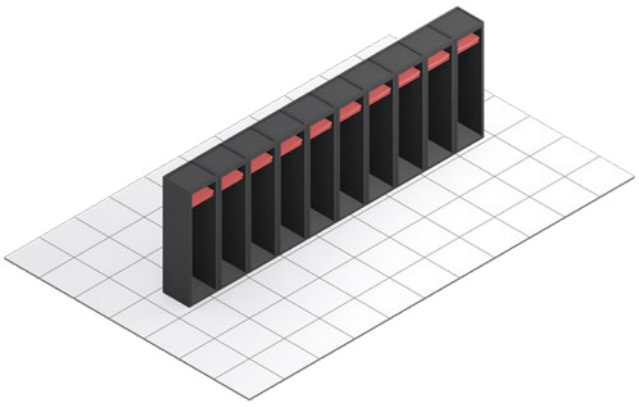
Bayface from a row of 10xEDAs (Server Racks) and 1xMDA.

T.o.R. *(Top-of-Rack)*

Each EDA equipment rack has a piece of network equipment (switch) in its upper position, and connections to servers are made directly from this switch, with patch cords or active cables (AOC or DAC).



ANSI/TIA-942-B



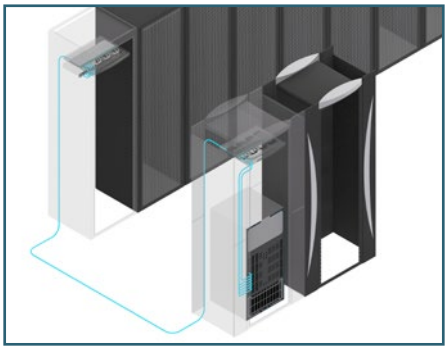
Analysis of the advantages and disadvantages of this topology:

ADVANTAGES

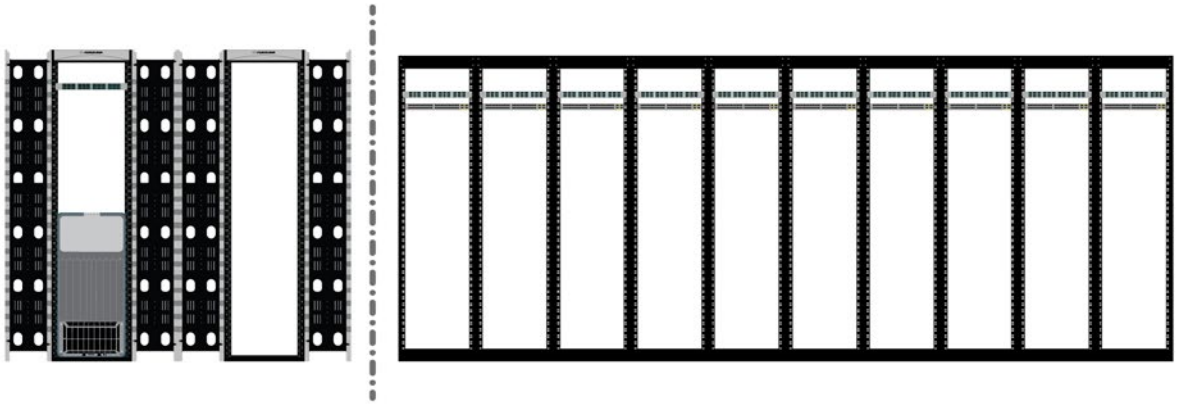
- In most cases, it uses cabling more efficiently.
- Efficient use of space.
- Good scalability.
- Easy cabling management.
- Easy interconnection of servers and ToR *switches*.
- Fast addition of new equipment.
- Very low cabling density, which reduces the need for space under the raised floor.
- Fast installation.
- Small space required for cable distribution racks.

DISADVANTAGES

- Server interfaces and connection cables for ToR switches are not as cost effective as patch cords in structured cabling.
- More options for managing active network equipment.
- Higher number of ports for traffic aggregation (aggregation or distribution switches).
- Larger quantities of STP ports in aggregation.
- More traffic from server to server.
- Higher cost of assets (switches).
- Thermal management risks.
- Creation of *hotspots*.
- Excessive equipment and network ports.
- Separate administration and maintenance in each rack with ToR switch, which increases network complexity and reduces network reliability.
- Flexibility limited to the services offered by ToR switches.
- Network segmentation only by virtual means (VLAN, Fabric SAN), which may counter the existing information security policies of the client.
- Additional cooling and power needs in each rack with ToR switch.
- Implementation of difficult and costly high availability schemes.
- Requires a large number of links and redundant features, such as power supplies, administration modules and ***backbone*** ports.
- Unless the networks are 100% integrated, it must be complemented with other cabling schemes for SAN, redundancies, consoles, security and management networks etc.
- Does not allow intelligent monitoring and administration of cabling for server connections.



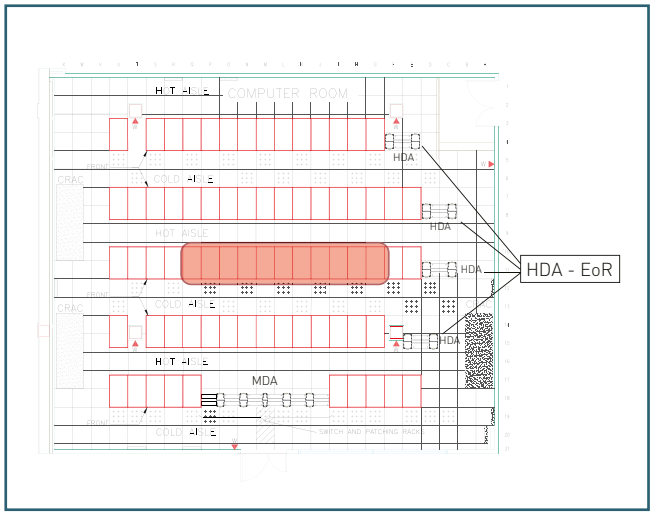
Product Demonstrated application to meet high density ToR topology.



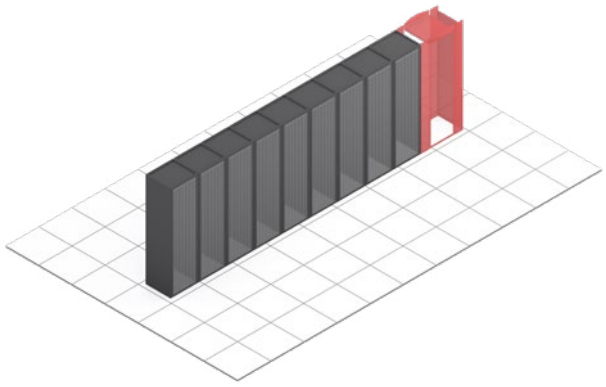
Bayface of a row of Racks: 10xEDAs ToR (serve racks) e 1xMDA

E.o.R. *(End of Row)*

The HDA *rack* is positioned at the end of the server *rack* row and the horizontal network cabling serves the EDA *racks* from this point.



ANSI/TIA-942-B



Analysis of the advantages and disadvantages of this topology:

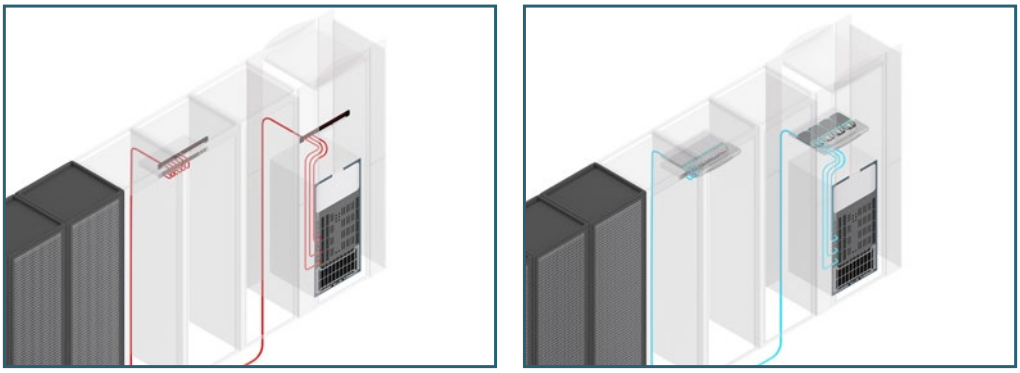
ADVANTAGENS

- Fewer cables than the direct connection architecture between HDA and MDA.
- Very good scalability.
- Easy interconnection between servers and network devices.
- Fast insertion of new hardware into racks and the network.

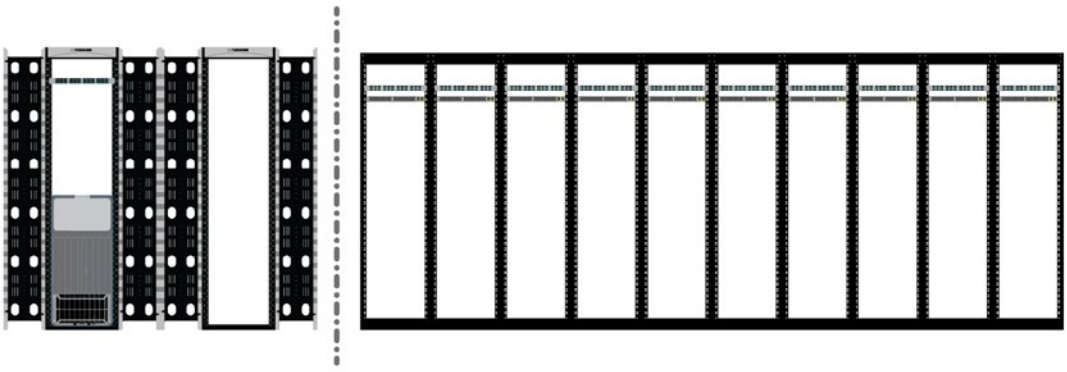
- Very low cabling density, reducing the space required in the infrastructure under raised floor.
- Fast installation.
- Little space required in the cabling distribution racks.
- Interfaces and patch cords for servers with good cost-benefit ratio.

DISADVANTAGES

- Too many switches and network ports distributed throughout the Data Center.
- Separate administration and maintenance in each EDA rack with ToR, which increases complexity and reduces network reliability.
- Flexibility limited to the services offered by the ToR switch.
- Network segmentation by virtual means only (VLAN, Fabric SAN), which may counter existing security policies.
- Additional cooling and power needs per EDA rack.
- Implementation of high availability (redundancy) schemes that are difficult and costly.
- Requires a large number of links and redundant features such as power supplies, administration modules and backbone ports.
- Unless the networks are 100% integrated, it must be complemented with other cabling schemes for SAN, direct redundancies, consoles, security networks etc.
- Does not allow intelligent monitoring and administration of cabling for server connections.



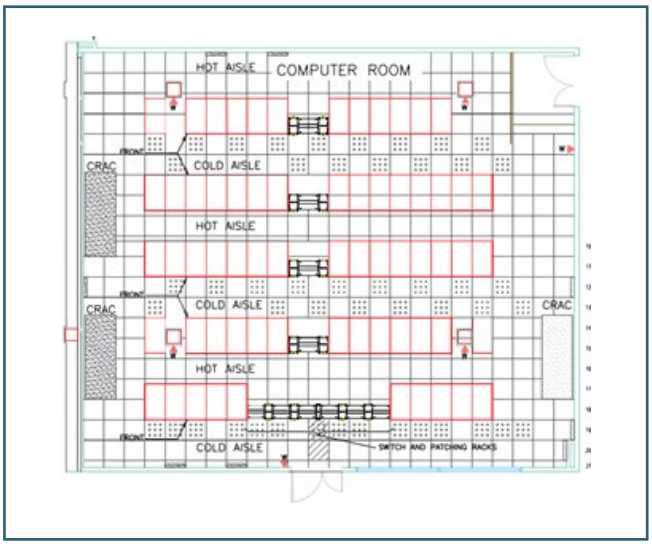
Demonstrative application of fiber and copper products needed to meet a high-density EoR topology.



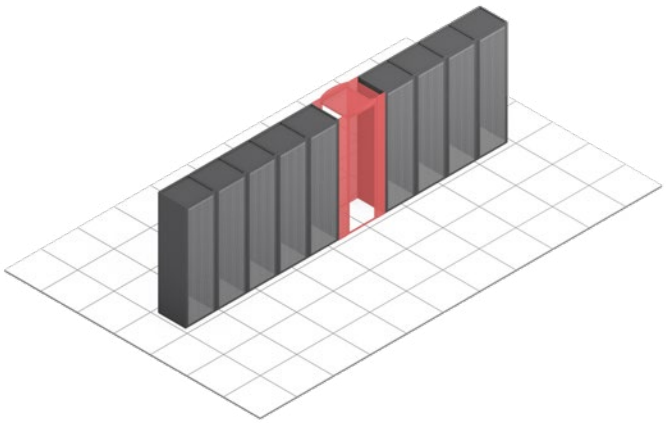
Bayface of a row of Racks: 10xEDAs ToR (server racks) and 1xMDA.

M.o.R. *(Middle-of-Row)*

The HDA ***rack*** is centralized in the server rack queue and the horizontal network cabling serves all EDAs ***racks*** equidistant.



ANSI/TIA-942-B



Analysis of the advantages and disadvantages of this topology.

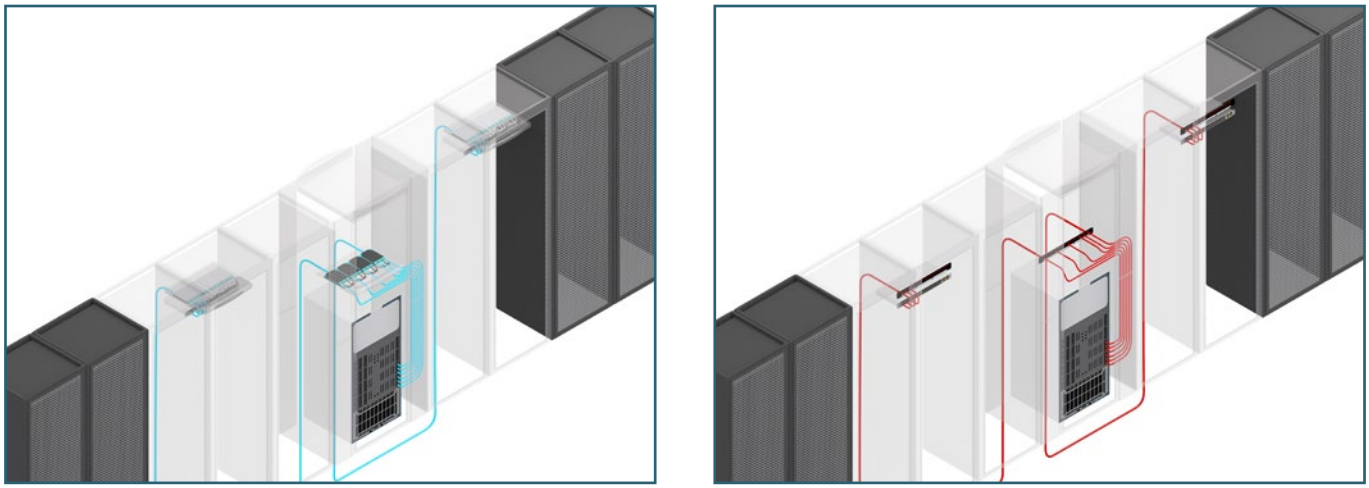
ADVANTAGES

- Cables with shorter physical lengths.
- Fewer cables than the direct connection architecture between HDA and MDA.
- Good scalability.
- Relatively easy to mount server interconnection to network assets.
- Fast addition of new equipment.
- Very low cabling density, which reduces the need for space under the raised floor or in the infrastructure.
- Fast installation.
- Reduced space for cabling distribution racks.
- Interfaces and server connection cables (patch cords) have a good cost-benefit ratio.
- Doesn't require many network ports like in the ToR architecture.

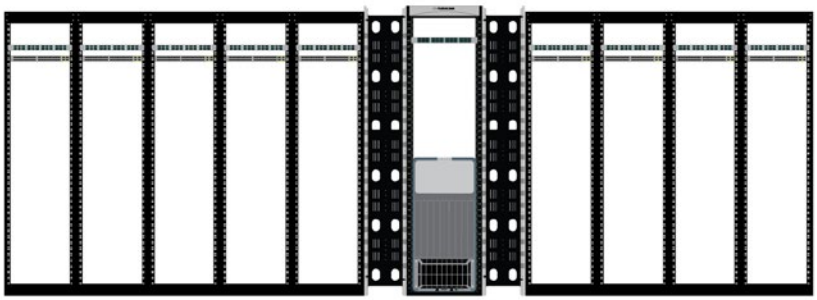
DISADVANTAGES

- Increased asset (***switch***) cost on the ***rack*** (MoR).
- Increased management overhead.
- Significant excess equipment and network ports.
- Separate administration and maintenance in each group of ***racks***.
- Flexibility limited to the services offered by the MoR ***switch***.
- Virtual-only network segmentation (VLAN, Fabric SAN), which may counter existing information security policies.
- Additional cooling and power needs in each ***rack*** group.

- Unless the networks are 100% integrated, it must be complemented with other cabling schemes for SAN, redundancies, consoles, security and management networks etc.
- Does not allow intelligent monitoring and administration of cabling for server connections.
- Interconnection between different ***racks*** in the same row requires very long cables, which can mean lifting many raised floor panels, which in addition to delaying implementation, puts network points that are in production at risk of stopping.
- Interconnection between ***racks*** in the same line can lead to the opening of ***racks***, which are between ***racks*** to be interconnected, which may counter the existing information security policies of the client.



Demonstrated application of optical and copper products required to meet a high-density MoR topology.



Bayface of a row of Racks: 10xEDAs ToR (server racks) and 1xMDA

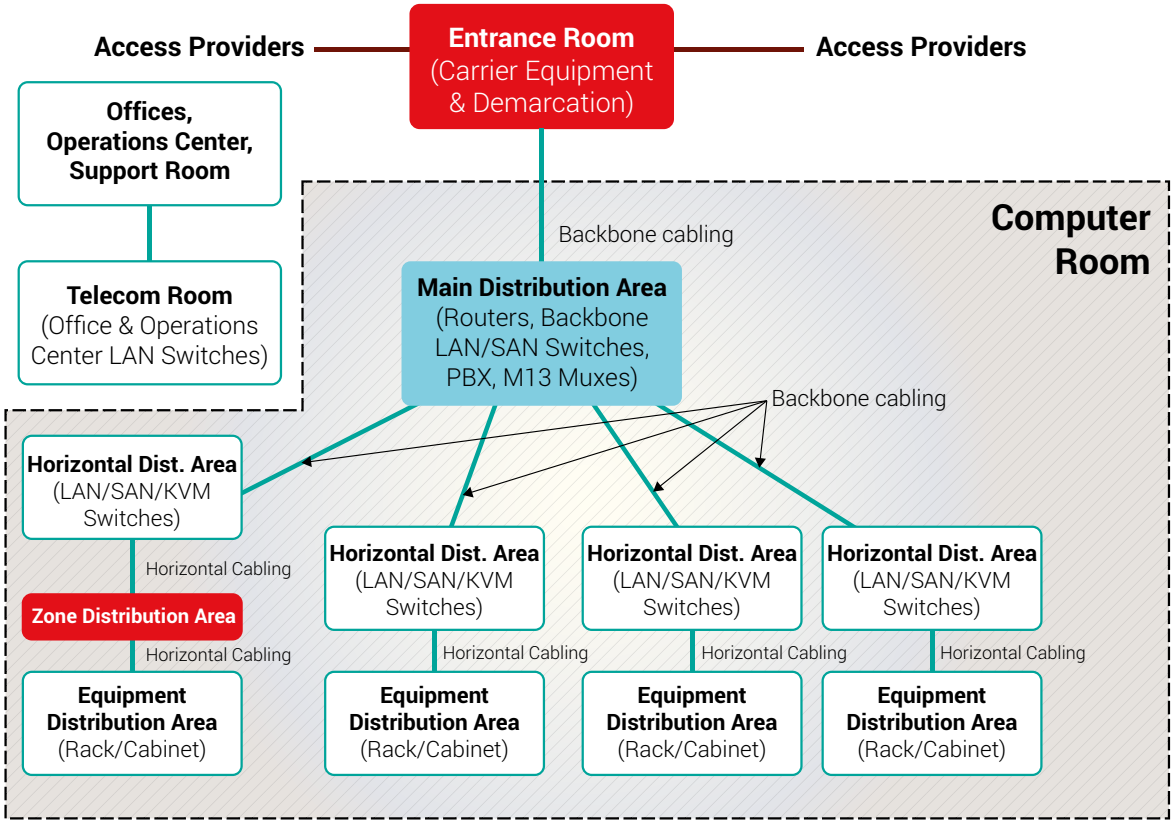
The topologies define the logical and physical connection of the network equipment to the information traffic and connection of the equipment.

In network architectures, it will be defined how the equipment will be connected considering a division into layers for better management.

2.8. Network Architectures

The Annex H (informative) of ANSI/TIA-942-B shows that when built in a hierarchical and structured way, some more complex aspects in a Data Center are minimized, putting the whole structure in a perspective of easier assimilation. The hierarchical model built in networks is composed of three layers (core, distribution and access) and has its equivalence in the Data Center:

- **Core:** responsible for transporting large amounts of traffic reliably, quickly and provide network interface between DC LAN network and Telecom operators' WAN network. Any fault affects all network users (Lobby + MDA & IDA).
- **Aggregation (Distribution):** Determines the fastest way to meet a request for a specific network service and delivers the route to the core layer (HDA).
- **Access (Edge):** Controls access to data center resources - servers and storage devices (Storage/Disks) (EDA).

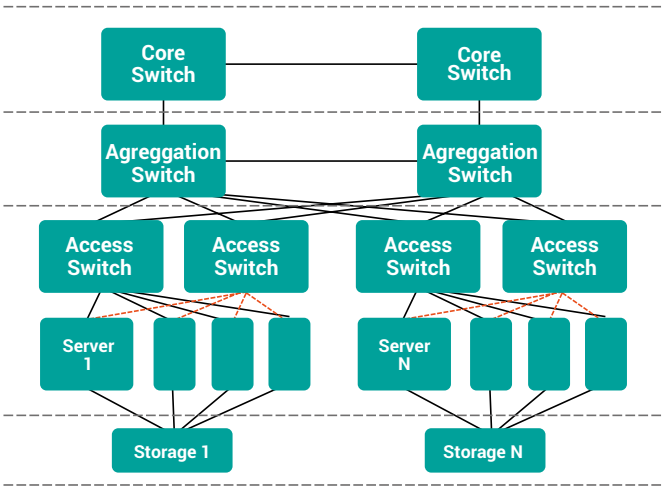


There is a direct relationship between the basic topology proposed by ANSI/TIA-942-B and the hierarchical star topology: the network architecture of the Data Center consists of layers. Thus, it has performance, flexibility, scalability, resilience and management. Below will be presented some of the architectures most used by clients.

Layer Architecture

Used by 90% of *Edge* Data Centers and small and medium size.

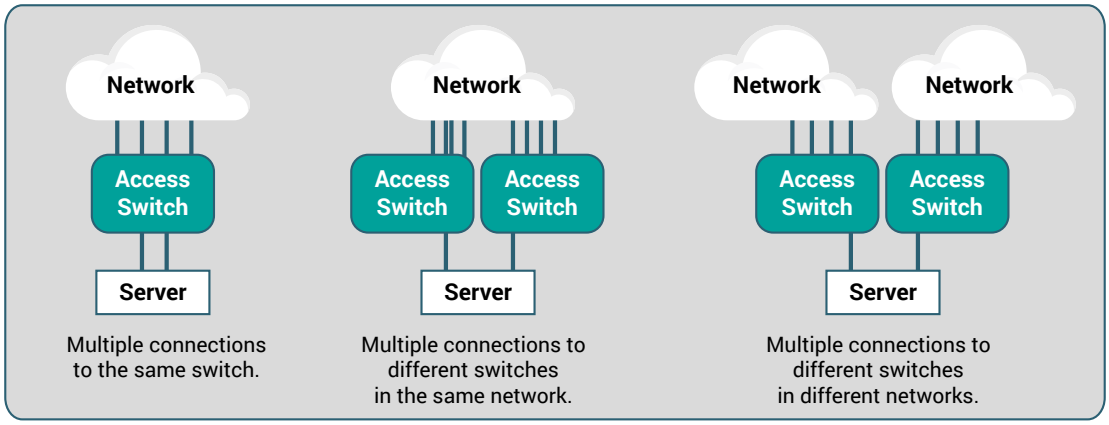
Some of the features of the traditional three-tier switch architecture:



- *Backup* connections (the dashed lines in the figure on the side). To access *switches,* they are not used for spanning tree protocols.
- Connections are usually over-subscribed, that is, more traffic is assigned to the link than the link's bandwidth capacity, leading to the need for administration of that link.
- When access ***switches*** are located in the EDA (i.e., top of ***rack***), more ***switch*** ports may be available in each cabinet than necessary.
- Traffic between two access ***switches*** may need to cross up to three intermediate ***switches***.
- The traditional architecture is well-suited for traffic between servers on the same access ***switch*** and from servers to external destinations. However, it isn't suitable for large virtualized Data Centers where compute and storage servers may be located anywhere in the Data Center.

Multiple Connection Architecture

Used by 90% of ***Cloud Computing***, ***Hyperscale***, ***IDC*** or large Data Centers.



Single Line Diagram

Servers and storage usually have multiple connections to provide redundancy, additional bandwidth or to support different functions. Connections can be to a single switch, to multiple ***switches*** within the same network, or to multiple ***switches*** on different networks. The objective of this architecture is to maintain a large data flow, in a safe way and with alternative routes in large scale, widely used in major Internet search engines, which use high availability and high-density optical port networks and with installations in several regions of the world.

In this scenario of ***Cloud Computing***, focusing on the client's business and the low response time required by the current market, also stands out the architectures coming from virtualized network systems, in an operating system with open source code: SDN/NFV.

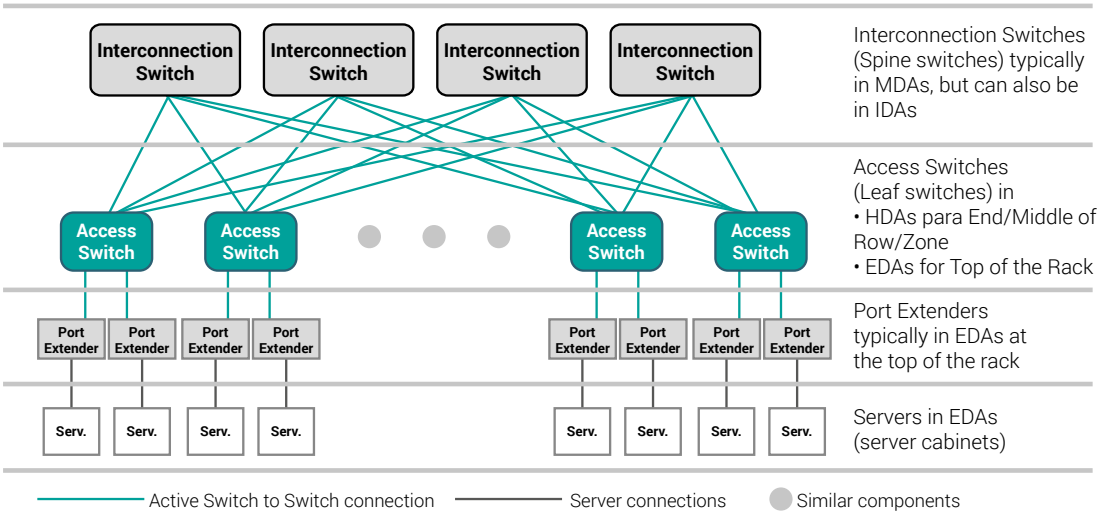
In them, network resources are managed virtually and automatically, from one or several servers, with open operating systems. When integrated, they operate network ***switches*** and routers as a single logical entity, interconnecting all network bare ***switches*** under a single software that manages, provisions and monitors all network resources. In addition, it maintains scalability, resiliency, redundancy, availability and reliability for Hyperscale Data Center ***mission-critical*** operations, regardless of location, server/storage density and server room operating conditions.

SPINE-LEAF ARCHITECTURE

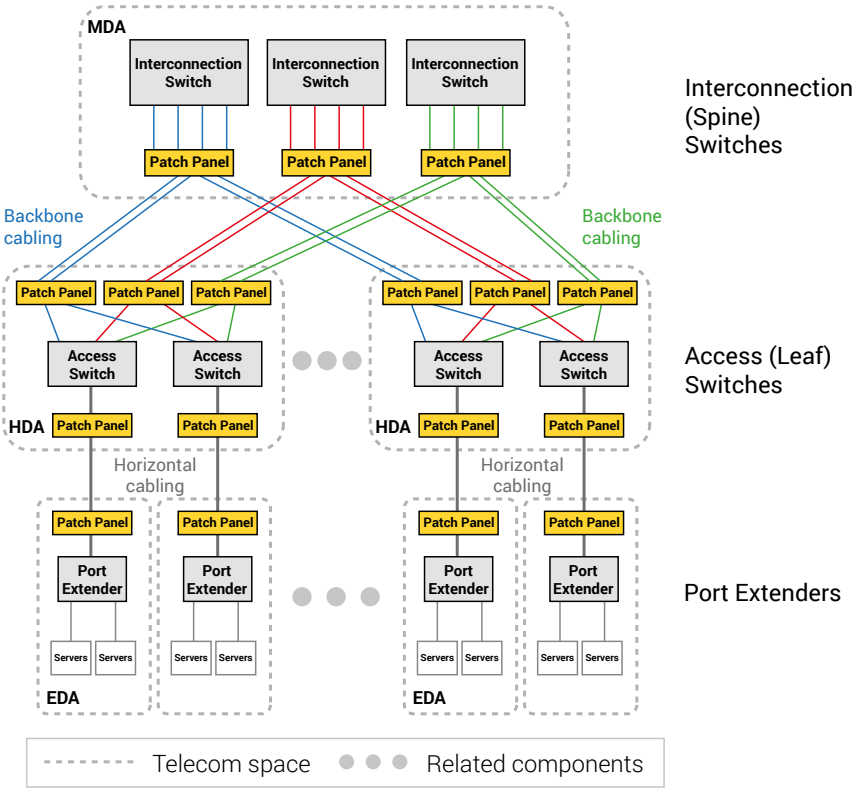
One of the subtypes of multi-connected architecture, **Spine** architecture, is used by most medium and large data centers, including corporate DCs of large multinational companies. E.g. ***Commodities*** Sector - Oil/ Gas, Energy and Mining and Consumer Goods Sector - Automotive.

FAT TREE

All interconnection ***switches*** are interconnected with all access ***switches***, maintaining a high level of route redundancy with non-blocking ***topology***. With this, the Data Center has high resilience, availability and reliability. Used in medium and large Data Centers.

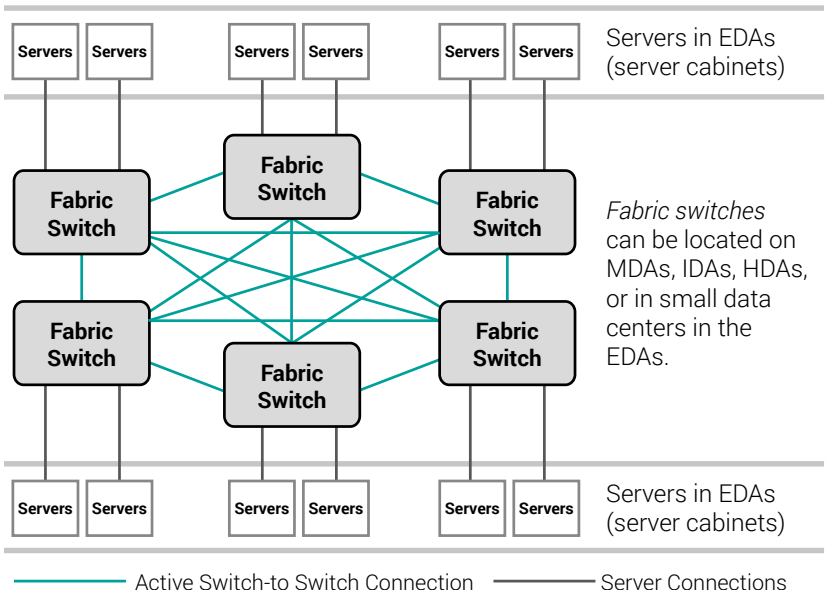


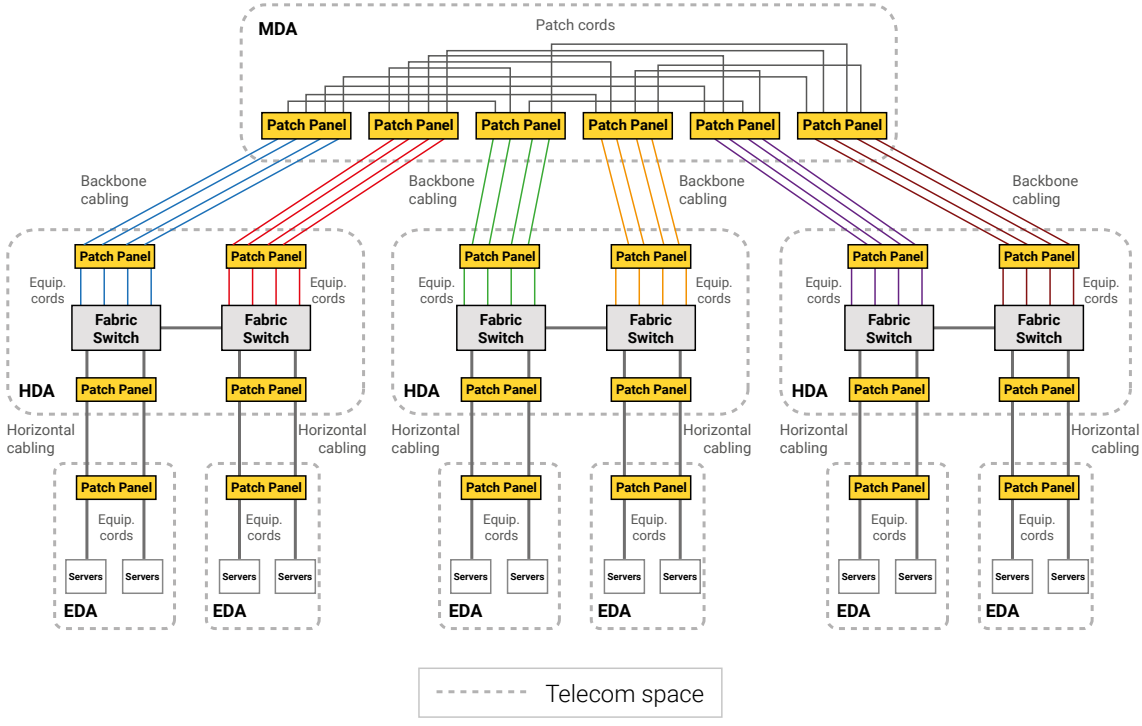
Wiring diagram suggested by ANSI/TIA-942-B for Fat Tree Network Architecture



SWITCH FABRICS

Used to increase the performance of Data Centers with high speed and high availability networks, according to ***the Full-Mesh architecture***. Widely applied in ***Cloud Computing*** and ***Hyperscale*** Data Centers, widely used in the financial and banking sector around the world.

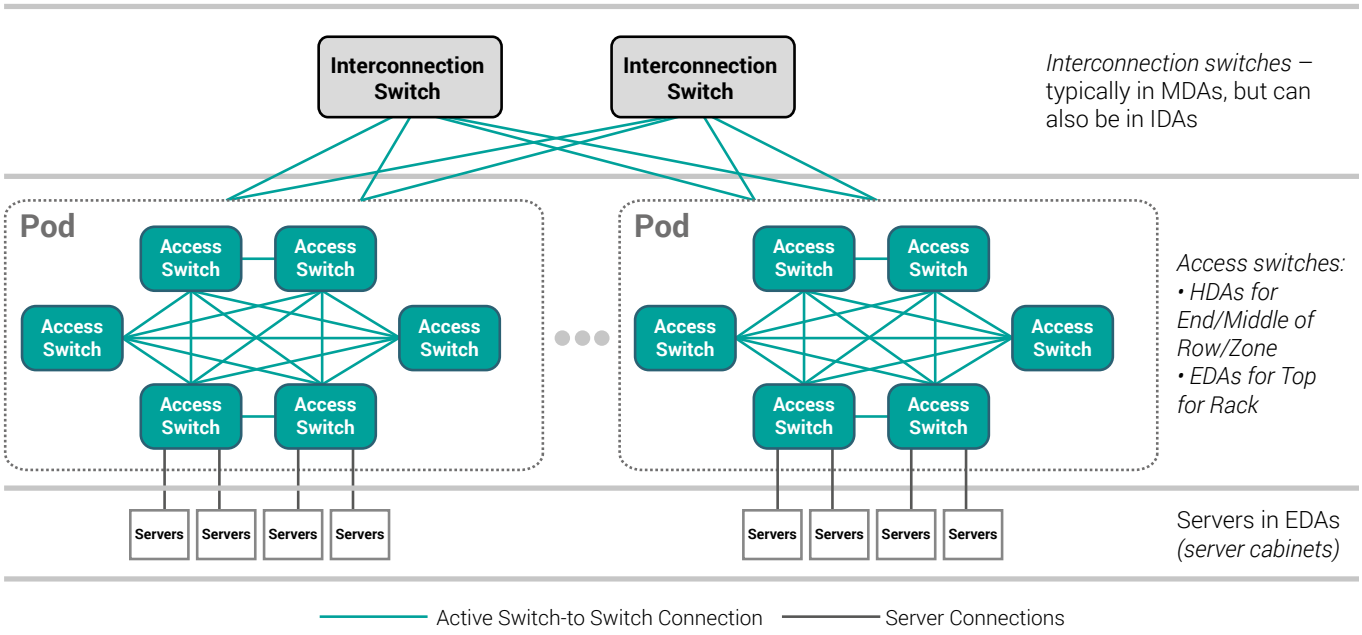




Wiring diagram suggested by ANSI/TIA-942-B for Full Mesh Network Architecture.

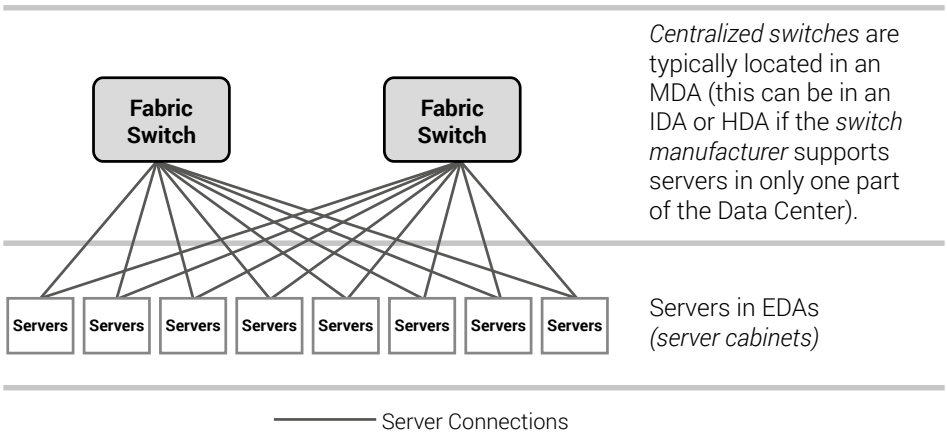
INTERCONNECTED FULL MESH SWITCH FABRICS + POD

The figure below is an example of the interconnected ***switch*** "mesh" architecture. This architecture has between one and three intermediate ***switches***, between any two access ***switches***. Typically, it is ***non-blocking*** within a POD (Part of Data Center) and cannot be ***non-blocking between*** the PODs. It is the typical architecture of ***Hyperscale*** Data Centers.



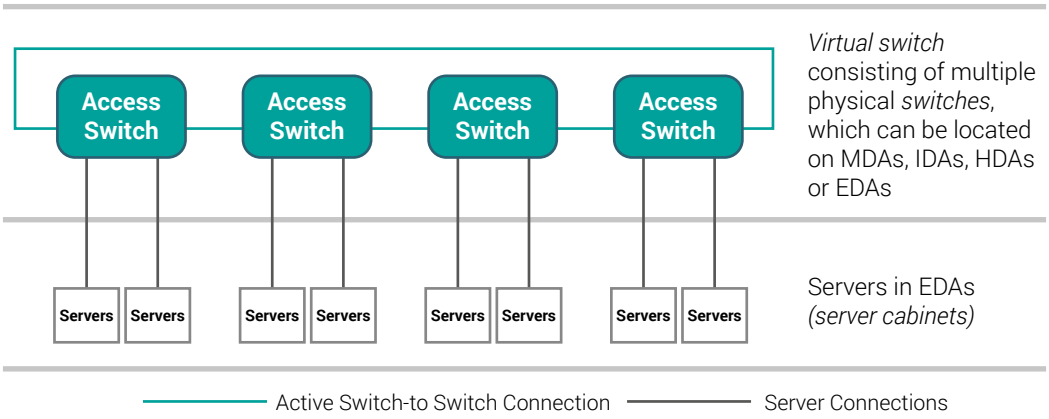
CENTRALIZED SWITCH FABRICS

The figure below is an example of typical Edge Data Center architecture. They are physically small, often located very close to or even within clients, but with large network, processing and storage capacity. They can also be moved to any place, because many are modular or mounted in "***containers***", which facilitates their displacement. When they are grouped together in a large park, they can be called the POD (***Part of Data Center***).



VIRTUAL SWITCH FABRICS

The figure below is also an example of typical **Edge** Data Center architecture. However, in this case, the ***switches*** distributed in the form of a redundant ring stand out, which doubles the speed of your network, but also increases the number of physical equipment and connectivity in the network. Therefore, there will be more ToR (Top of Rack) ***switches*** and more ***patch panels*** in the EDA ***racks***, but there is no latency in the hierarchical architecture.



DID YOU KNOW?

The network architectures define how the equipment will be connected considering a division into layers for better management. This definition is linked to the purpose of the Data Center, each of which is characteristic for one activity or another. In the topologies, we will define the logical and physical connection of network equipment, for the traffic of information and connection of equipment.

3 Components

We live in a highly connected environment, generating huge amounts of information, leading to a growth in global network traffic, as well as data storage on social networks, the Internet of Things, Industry 4.0, and more. The Data Center should be prepared to support all this traffic, which tends to increase exponentially. The cabling infrastructure shall use specific components, specially developed to enable the high volume of data present in this environment.

In this chapter, you'll find out which components are indispensable for building the network infrastructure of a Data Center, its main parameters and configurations.

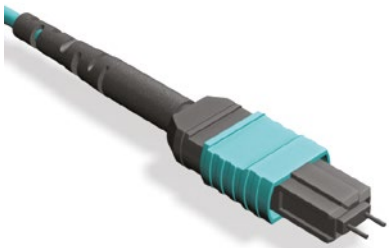
3.1. Pre-terminated System Concepts

Structured cabling systems that use pre-terminated cables are recommended for ***plug-and-play*** applications where ease of installation is critical. Commonly used in optical channels, these systems allow the channel to be mounted without the need for fusions between the components.

MAIN ADVANTAGES:

- Flexibility and modularity, with optimization of physical space.
- Scalability and ease of expansion without quality degradation.
- Quick and easy installation and reconfiguration.
- Simple handling, no special tools required.
- High performance in the connections.
- When designed, it supports current and future data transmission rates.

To ensure all the benefits that a pre-terminated system offers, you must analyze the topology and choose the right components to meet the requirements of the application to be supported.



Male MPO connector (with guide pin)

MPO CONECTOR (MULTI-FIBER PUSH ON)

These are multi-fiber optical connectors that can support from 04 up to 72 optical fibers in a single connector. Initially, its application aimed at optimization in the optical backbone, replacing the passage of several cables of one or two fibers. Currently, there is a new focus with the development of applications for 40 Gbps and 100 Gbps, in addition to new applications for 200 Gbps and 400 Gbps in multimode optical fibers, and in Transceivers with MPO connectors.

Female MPO connector (without guide pin)

Currently, the most used applications include 12-fiber connectors.They are available in male (with guide pins) or female (without guide pins) versions, and there must always be a connection between a "male" element and a "female" element.

Attention: The connection between two "female" connectors will not provide the perfect alignment of the fibers (the guide pin is essential to ensure the alignment of such) and the system will suffer loss of performance. Connecting two "male" MPO connectors, with the presence of a guide pin on both sides, will cause damage to the connector structure.

Note: The MTP© connector is a type of MPO connector. Both are fully compatible and can be used together in high performance systems. The IEEE802.3ba standard, referring to Ethernet transmissions up to 100 Gbps, defines MPO connectors as interfaces. This is therefore the nomenclature used here. As the MTP is a type of MPO, it is included in all items that refer to MPO elements in this document. MTP© is a registered trademark of USCONEC.

MPO ADAPTER

MPO adapters are elements that align two MPO connectors. They have polarity according to the position of the connector keyway.

Adapter with polarity TYPE A brings one keyway up and one down. The two connectors are connected at 180° in relation to each other. Black in color

Adapter with TYPE B polarity shows two keyways on the same side. The connectors are connected 0° in relation to each other, both are in the same position. Gray in color.

UNIVERSAL CONNECTOR MPO

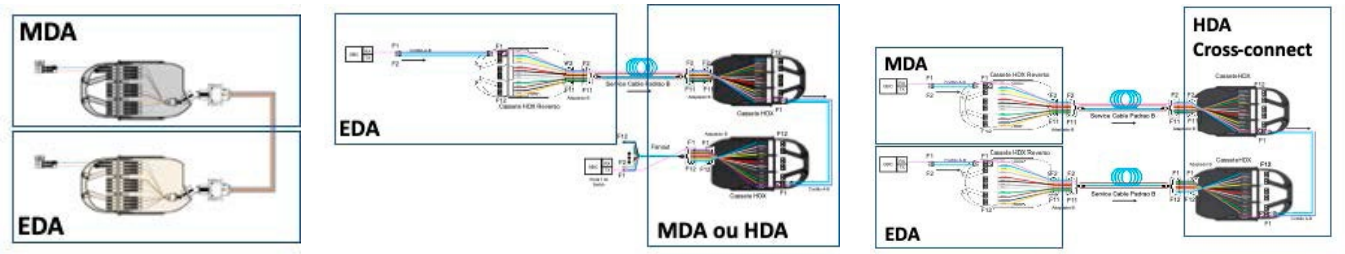
Note that the MPO connectors must be compatible in terms of gender and polarity (see item 3.2). The correct operation of a MPO Optical channel depends on the correct combination of these two variables to be functional. In order to facilitate the design of the optical channel and ensure compatibility with legacy networks (which may have different gender and polarities from the products currently supplied), the MPO Universal connector was developed, which allows the gender of the connector to be changed from male to female and vice versa, and from key-up/***key-up*** to ***key-up***/key-down and vice versa. In addition to the benefit of greater flexibility in the design and maintenance of MPO Optical channel, the management of optical components is gained by the smaller number of parts required in stock.

Changing the gender of the MPO connector from male to female.

LOW-LOSS AND ULTRA LOW-LOSS MPO

Several connection topologies are foreseen in the ANSI/TIA-942-B Data Center standard. To ensure that the optical channel supports the requirements of current and future applications that will be transported by this cabling, it is essential to consider the optical insertion losses of the optical link. MPO components are important components of these optical losses.

The use of low-loss and ultra-loss MPO components ensures an optical channel with performance parameters compatible with higher speed applications and provides greater flexibility in choosing the desired connection topology because they have lower optical loss (IL) limits optimized to support existing and upcoming transmission rates.



Examples of MPO channel schemes.

MPO BASE 8/12/16/24/32 CONNECTORS

The development of equipment with MPO connectors has brought the possibility of parallel transmissions using several fibers. This optimizes the number of transceivers in a device with higher transmission capacities. The use of MPO connectors with 12 and 24 optical fibers with parallel transmissions of 8 fibers (4 fibers transmitting and 4 fibers receiving signal) and 20 fibers (10 fibers transmitting and 10 fibers receiving) respectively, ends up generating a waste of resource, impacting on infrastructure and port density in IODs (Internal Optical Distributors). Thus, it was generated what is called Base 8, an MPO connector with 8 fibers.

In addition, there are other transmission Standards for 200Gbps and 400Gbps applications with 16 and 32-fiber connectors that are being standardized.

3.2. Polarity

All methods of optical connectivity have the same purpose: to create a communication path between the transmission port of one equipment and the reception port of the other equipment. There are different ways to achieve this goal, but they are not interoperable. Therefore, we recommend choosing with caution and keeping the same pattern throughout the life of the installation.

Below, we present the Standards recognized by ANSI/TIA-568.3-D.

Standards

The ANSI/TIA-568-C Standard recognizes three methods for parallel transmission configuration:

TYPE A

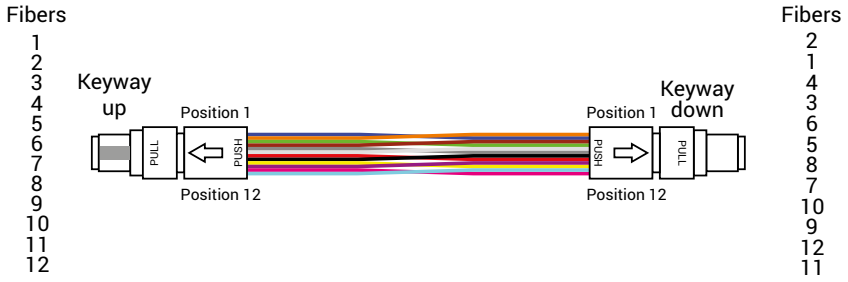
When mounting MPO-MPO TYPE A ***service cables*** ("trunk cables"), fiber 1 on one end represents fiber 1 on the other end.

TYPE B

When mounting MPO-MPO TYPE B service cables (“trunk cables”), fiber 1 on one end represents fiber 12 on the other end. In this case, the fibers are completely reversed.

TYPE C

When mounting TYPE C MPO-MPO ***service cables***, fiber 1 on one end represents fiber 2 on the other end. Only fiber pair inversion takes place (e.g. fiber 1 and 2 is considered a fiber pair or an optical channel).



Importance in the Project

Attention: the male/female pattern should always be observed, and, in general, the equipment has male type interfaces, therefore the cords/cables used should have female connectors.

Furukawa understands that the most suitable method of optical connectivity is **Type B**.

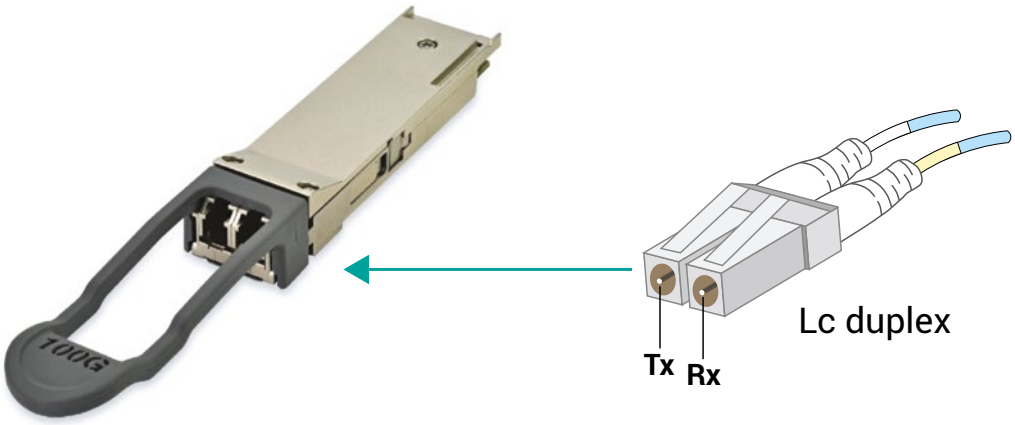
With all Type B cabling elements, future migrations from 1/10G networks to 40/100G or 200/400G networks or future speeds are made easier and thus products that are supply standards can be applied. This includes protocols not yet approved by the IEEE, such as: 40G BiDI, 40G SWDM and 100G SWDM and new transmission protocols: 800 Gbps 1.6 Tbps.

Source: Ethernet Alliance Roadmap 2018.

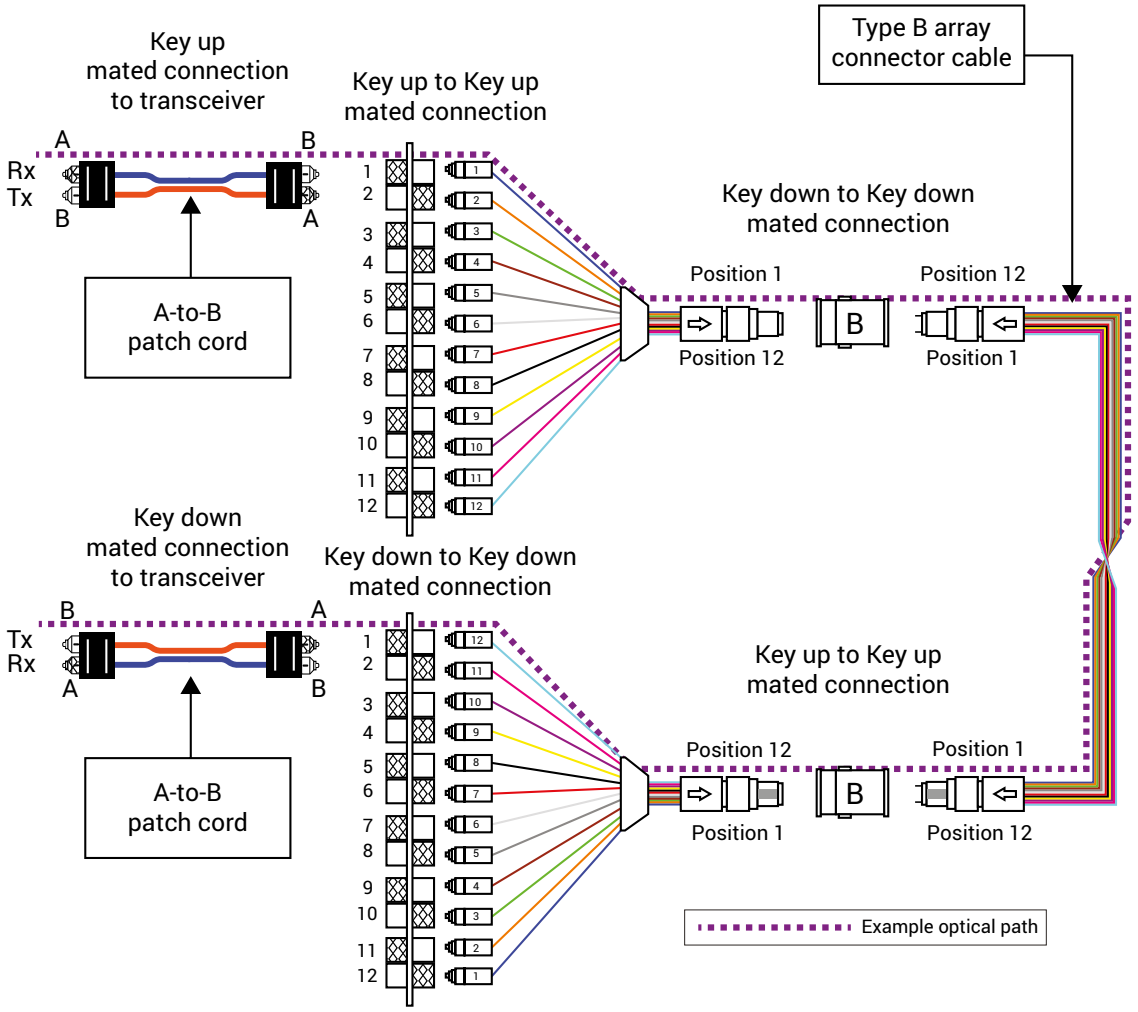
For channels with two or more connections it is necessary to check:

- The male/female standard for all MPO connections.
- The polarities of the products, taking into account that for transmission in 40G it is necessary to have an odd number or 100% of TYPE B components in the channel.
- Optical loss budget of the optical channel or Loss Budget which is the sum of the insertion losses (IL[dB]) of the passive optical components present in the channel according to ANSI/TIA-568-3.D.

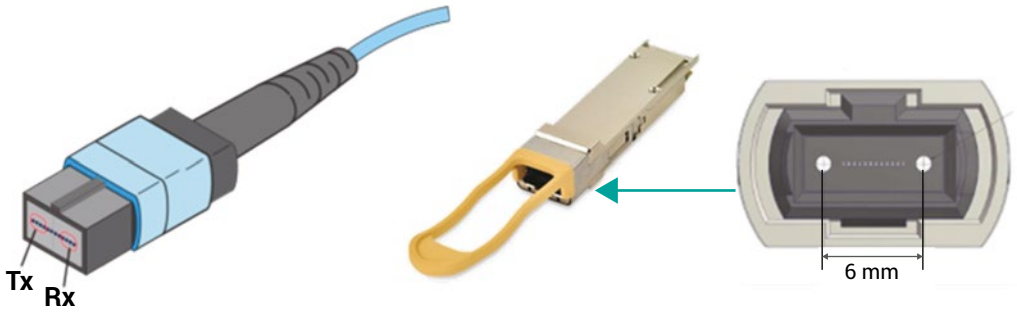
According to the ANSI/TIA-568-3.D standard, channels that run on an optical fiber pair, such as 1/10G/40G BiDi/40G SWDM4 (QSFP+) and 100GSWDM4 (QSFP28), can be configured as follows:



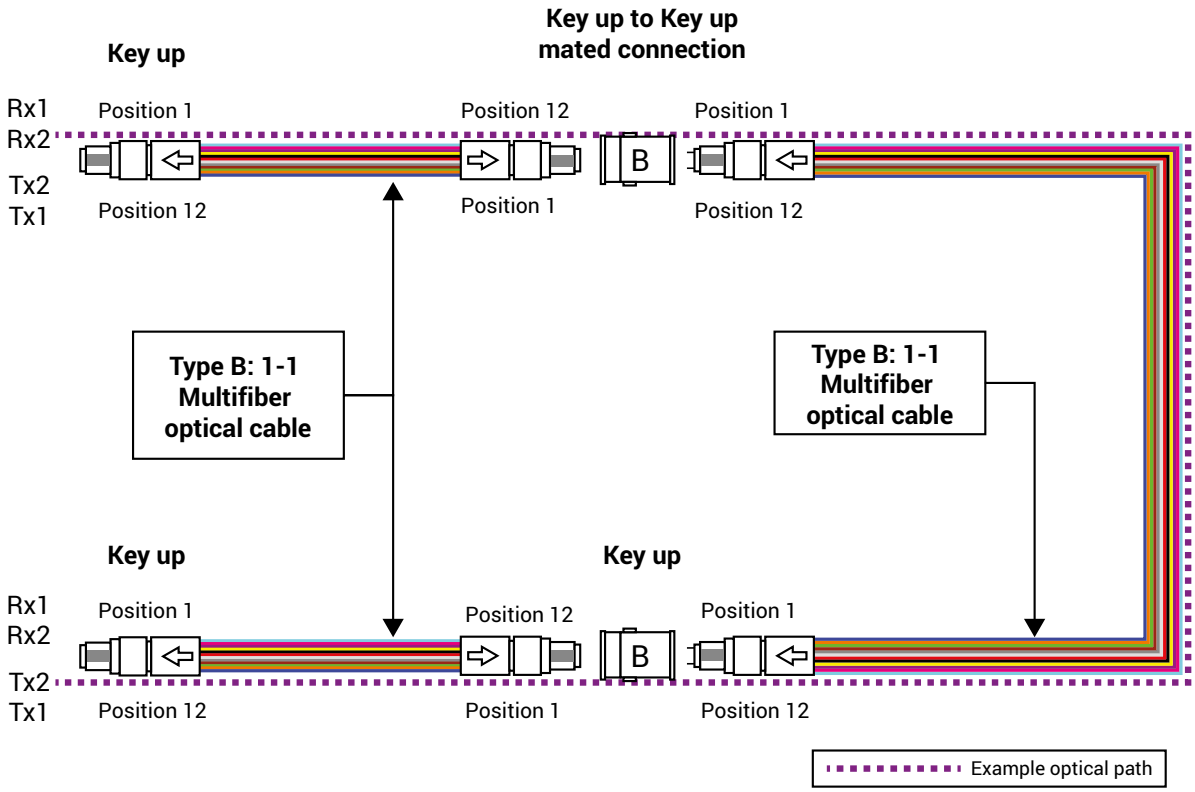
10 Gbps, 40 Gbps BiDi® - Transceiver SFP+.



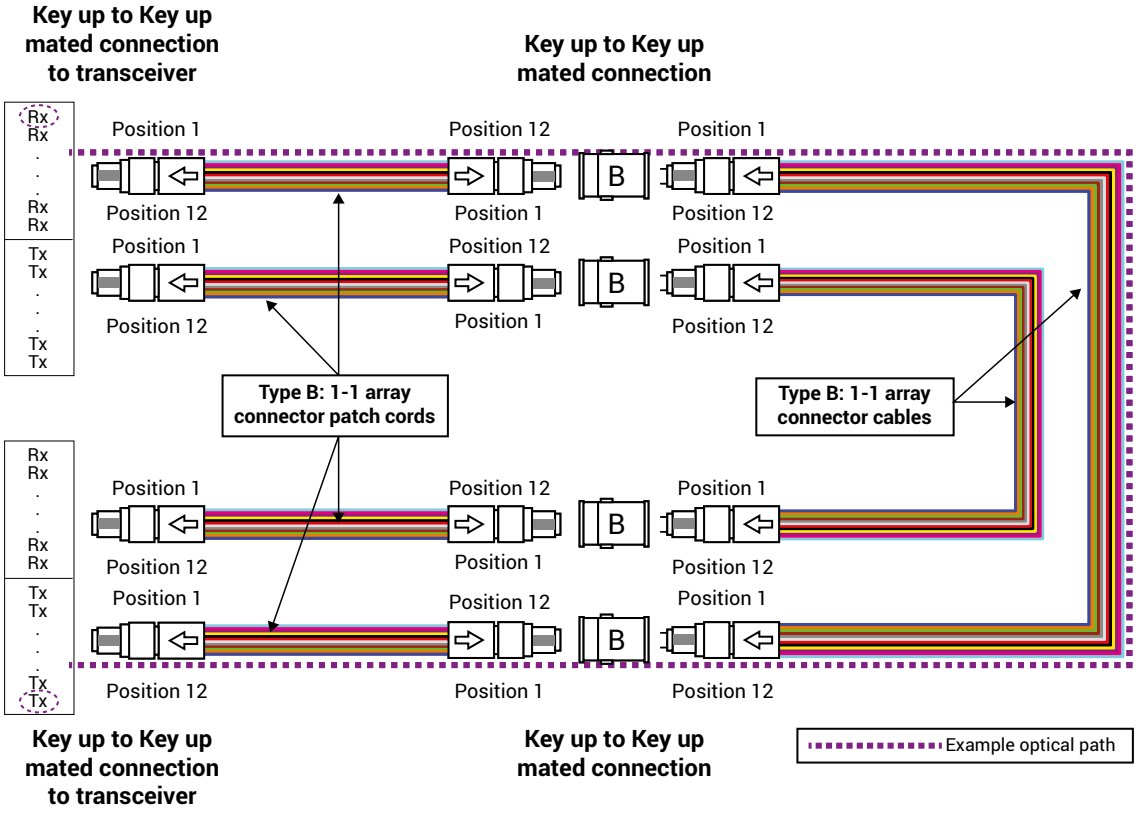
When designed for 40G/100G networks and other speeds using parallel fibers > 2F and MPO connectors, the following configuration must be used:

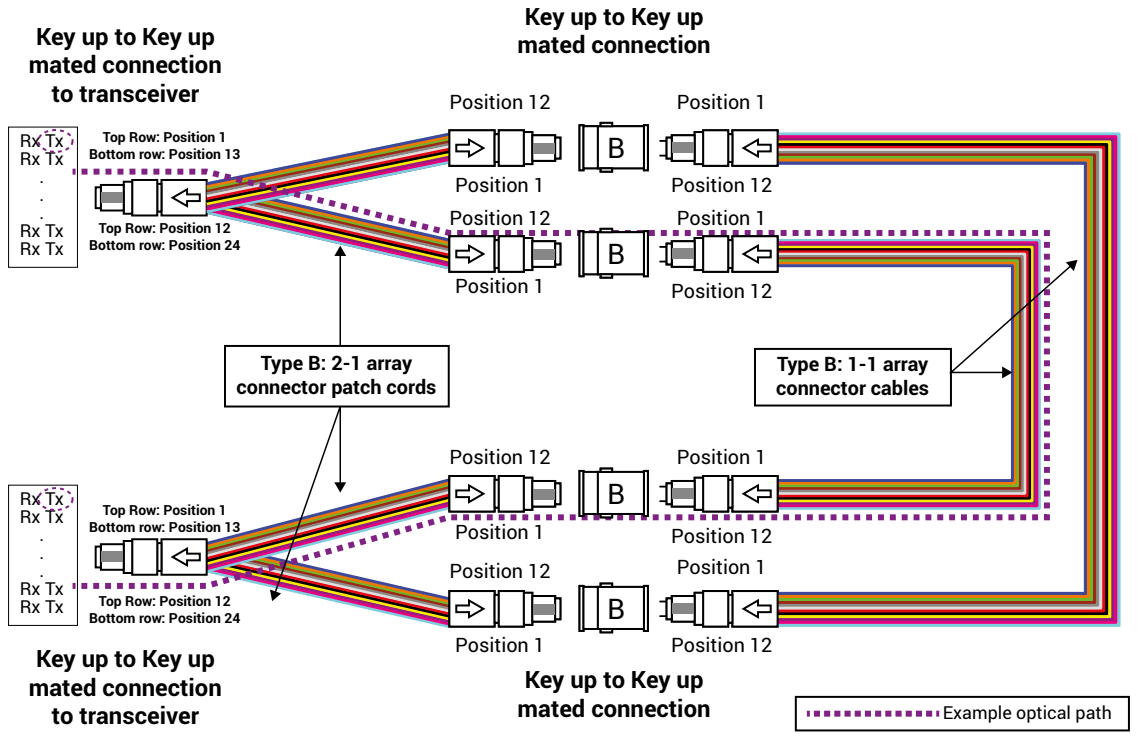


G-BaseSR - Transceiver QSFP+.



When designed for 100GBASESR10 networks that use 10 fibers for Tx and 10 fibers for Rx and MPO connectors in two separate interfaces, the following configuration must be used:

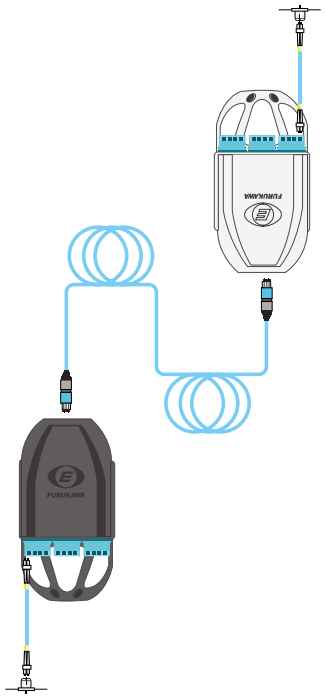


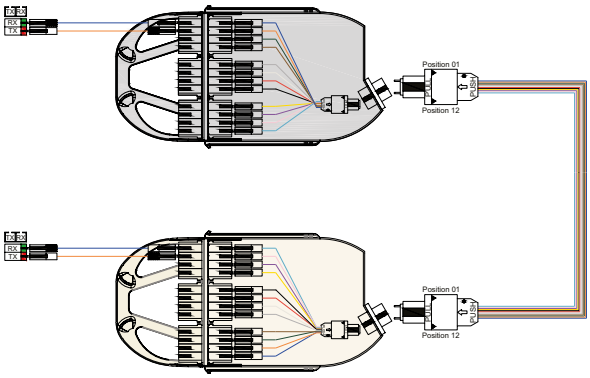


Note: A 100G network is considered using 4 channels of 25 Gb/s each, according to a study group formed by IEEE to standardize the 100GBASE-SR4 interface, published in March 2015.

Furukawa recommends the HDX line for the implementation of new channels, where:

- The HDX Cassette has a Female MPO.
- The ***Service Cable*** is used with male MPO and TYPE B polarity.
- A "Direct" cassette must be connected to each MPO tip, as well as a "Reverse" cassette on the respective tip on the other side of the cable.





3.3. Optical Fiber Performance

As with connectivity, the type of fiber to be used in a Data Center is also related to its functionalities and purposes. It is important to consider not only the polarity, architecture and topology, but also the application of the fibers.

Optical fiber connections can be **multi-mode (MM)** or **single-mode (SM)**. Multimode optical fibers – MM – have a range of up to 2 km (Ethernet 100BASE-FX) and have lower cost because they use LED or low-cost laser (VCSEL). The single-mode fibers – SM – reach up to 80 km, however, by using laser, they have a higher cost, compared to other fibers.

DID YOU KNOW?

The media recognized by ANSI/TIA-942-B for optical cabling are: single-mode (SM) and multimode (MM) fibers (OM3, OM4 and OM5), where OM4 is recommended.

MM - Multimode

Multimode optical fibers support a wide variety of protocols and application distances.

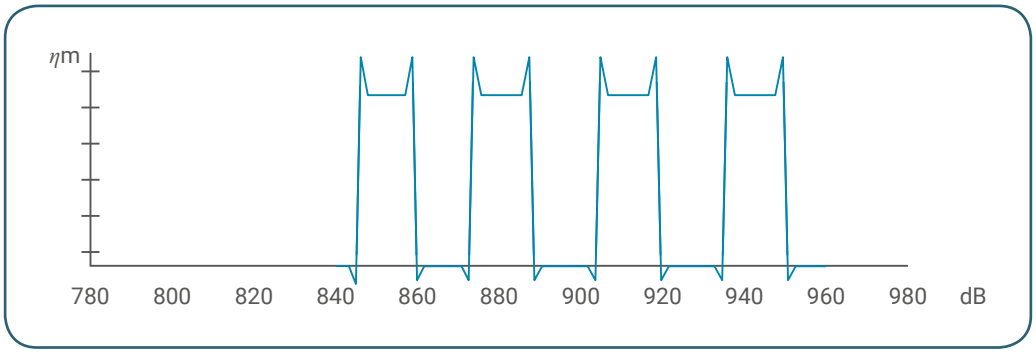
MM fibers for application in data centers must present specific characteristics that allow high transmission speeds and application ranges, also enabling the physical infrastructure to be prepared for current speeds and future generations of interfaces and protocols.

OM5

Developed for Wideband ***Laser-Optimized Multimode*** (SWDM) applications - standardized by ANSI/TIA 492AAAE - the OM5 fibers bring a new form of transmission, which is reflected in the reduction of data center infrastructure.

In the new OM5 multimode fibers, up to four wavelengths can be used, between 850 nm and 950 nm at the same time (ANSI/TIA-492-AAAE describes the bandwidth performance requirements for the wavelength of 953 nm, which did not previously exist). This feature is provided by SWDM (***Shortwave Wavelength Division Multiplexing***) technology, which brings a new form of transmission over multimode optical fibers.

The concept is equivalent to DWDM (***Dense Wavelength Division Multiplexing***) for single-mode optical fibers. The difference is that in SWDM, wavelengths of 850 nm, 880 nm, 910 nm and 940 nm are used.



Multimode Optical Fiber OM5 - Transmission Windows

With the increased bandwidth capacity of OM5 fiber, transmissions of 40 Gbps or 100 Gbps can be made over a single pair of fibers, using different wavelengths (850 nm, 880 nm, 910 nm and 940 nm). A 100GBASE-SWDM4 application, for example, can perform four 25 Gbps transmissions over a fiber pair at different wavelengths. This means a **four-fold reduction** in the amount of optical fiber required, less use of infrastructure, and easier management.

In the future it will also be possible to meet speeds of 200 Gbps and 400 Gbps with transmissions over a single pair of optical fibers. Undoubtedly, the SWDM technology on optical fibers OM5 opens new perspectives for the use of applications of 40G, 100G, 200G and 400G, with better use of infrastructure, equipment and space optimization in data centers. And OM optical fiber confirms the trend of evolution of the transmission capacity of multimode fibers.

OM4

Optical fibers of type OM4 are those denominated as laser optimized, with minimum EMB (effective modal bandwidth) of 4700 MHz.km at 850 nm, compared to 2000 Mhz.km for OM3. They are defined in the ANSI/TIA-492AAAD standard.

OM4 fiber is a 50 µm core fiber that has extended bandwidth. It can be used for transmissions of 1 Gbps, 10 Gbps, 40 Gbps and 100 Gpbs, supporting Ethernet, Fiber Channel and OIF applications, with a range of 400 meters in 10 Gbps and 150 meters in 40 Gbps and 100 Gbps.

3.3.1. SM - Single Mode

Single-mode optical fibers (***SM***) are mainly used when the distances between the points to be communicated are greater than the usual 150 meters (maximum application distance of OM5 and OM4 fibers) and/or when a higher transmission rate is required, given the bandwidth characteristics of this type of fiber.

SM optical fibers have different variants due to their performance and application parameters.

"LOW WATER PEAK" SM FIBER- LWP (G.652D)

Allows future network expansion to new users via CWDM on up to 16 channels, increasing transmission capacity by 50% over conventional single mode fibers. Low attenuation coefficient at peak water absorption (1383+-3 nm), ensuring additional use in the E-band (1360 to 1460 nm), as well as along the other transmission bands (1270 to 1610 nm).

They are defined in the ANSI/TIA 492CAAB / OS2 Standard.

"BENDING LOSS INSENTITIVE" SM FIBER- BLI (G.657)

Their differential is their low sensitivity to curvature, i.e., low values of loss by curvature throughout their spectrum of transmission, from 1260 to 1625 nm. These fibers are defined in the ITU-G.657 Standard.

There are two basic types of BLI fiber, A and B. Type A fibers (A1 and A2) have the same transmission parameters as conventional single mode fibers (G.652D) and are recommended for any application distance. Type B fibers (B2 and B3) are recommended for installations up to 1 km long.

A table with a summary of the fiber characteristics is presented beside.

Fiber type	Minimum radius of Curvature
G.652D	30.0 mm
G.657.A1	10.0 mm
G.657.A2	7.5 mm
G.657.B2	7.5 mm
G.657.B3	5.0 mm

3.4. Copper Performance

Copper channels support shorter distances, with greater latency and interference than optical fibers, and can be used in links up to 100 meters for categories below CAT.8. Category that has differentiated channel characteristics according to ANSI/TIA-568.2- D supporting up to 30 meters.

ISO Definition	ANSI/TIA Definition	Frequency
Class E	Category 6	250 MHz
Class EA	Category 6A	500 MHz
Class F	-	600 MHz
Class FA	-	1000 MHz
Class I	Category 8.1	1600 - 2000 MHz
Class II	Category 8.2	1600 - 2000 MHz

ANSI/TIA-942-B recognized media for copper cabling are CAT.6, CAT.6A and CAT.8, where CAT.6A is recommended.

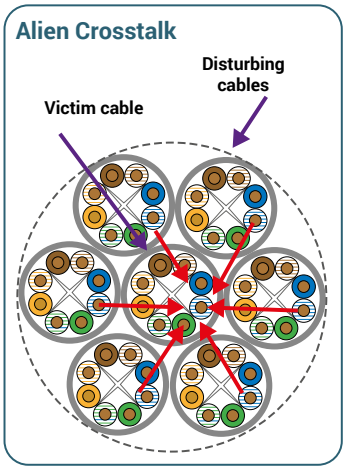
Fibre Channel (FC): Distances (m)					
	1 GFC	2 GFC	4GFC	8 GFC	16 GFC
Category	100	70	40	-	-
Category A	100	100	100	-	-

CAT.8

Category 8 was approved by ANSI/TIA in June 2016 and published in ANSI/TIA-568-C.2-1 in November 2016.

Category 8 cabling transmits 40 Mbps using a bandwidth of 2000 MHz, but had the maximum length of the channel reduced to 30 meters. The new interface that supports this speed follows the IEEE 802.3bq Standard (2016), with the name 40GBase-T.

The performance parameters for Category 8 are the same as for Category 6A, and ***Alien Crosstalk should therefore be considered in*** the certifications of the copper channel.



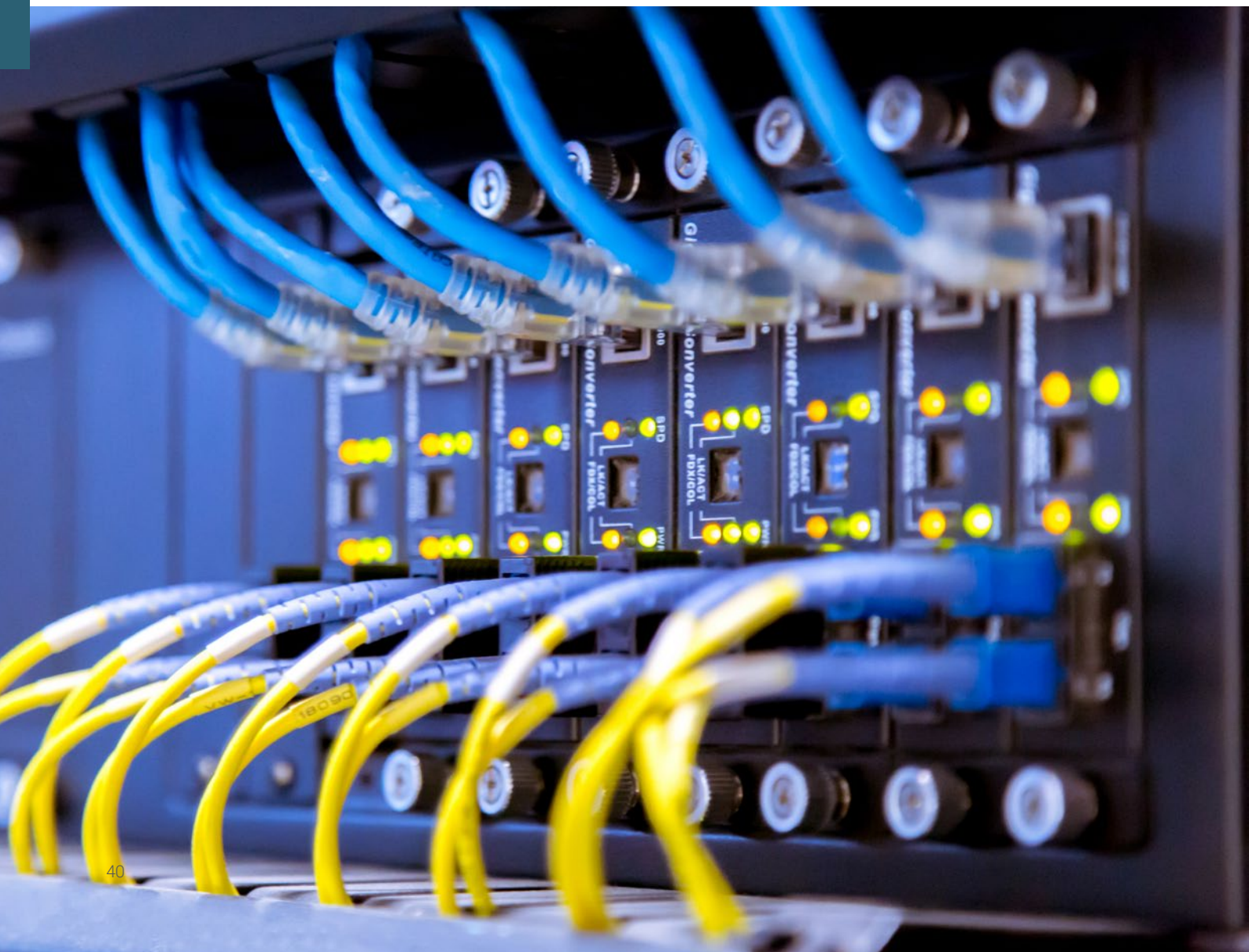
CAT.6A

Category 6A was approved by ANSI/TIA in February 2008 and was published as Annex 10 to ANSI/TIA-EIA-578-B.2 (ANSI/TIA-EIA-578-B.2-10).

Category 6A transmits at 10 Gbps with a bandwidth of 500 MHz, in copper cabling channels, up to 100 meters in total length. The interface that supports this speed follows the IEEE 802.3an standard (2006), with the name 10GBASE-T.

In addition to the performance parameters of Category 6 cabling, high-speed applications such as 10GBASE-T require signal interference to be controlled between adjacent cables as well. Interference between adjacent cables is called ***Alien Crosstalk***, having as new parameters evaluated the PSANEXT (***Power Sum Alien Attenuation to Crosstalk Ratio***) and the PSAACRF (***Power Sum Alien Attenuation to Crosstalk Ratio from the Far-end***).

The ANSI/ANSI/TIA-942-B Data Center Standard, in its 2017 edition, recommends Category 6A as a minimum transmission category in a balanced twisted pair of four pairs/100 Ohms.



4 Protocols

A fundamental part of data transmission, the protocols used in data centers must be evaluated and selected according to the required application and performance.

It is also common in large data centers for complex protocols to overlap or for multiple protocols to be applied simultaneously.

In this chapter, get to know the main data transmission protocols used today and how they will evolve.

4.1. Ethernet

Predominant protocol in networks around the world, it also represents the vast majority of connections in data centers.

The part of the network that is commonly called "LAN" by administrators in data centers and that promotes connections between routers, ***switches*** of various levels, and even servers in different topologies is, in most cases, connected using this protocol.

Ethernet interfaces began to be commercialized in the early 1980s and is standardized by the 802.3 Working Group of the IEEE (***Institute of Electrical and Electronic Engineers***).

From the beginning of commercial usage to the present day, speeds have multiplied to meet the growing demand for diverse services and web applications, voice, video, and, lately, aids in the connectivity of the Internet of Things (IoT).

As functional units of the cloud, Data Centers store and process huge amounts of information in very short time intervals.

To maintain availability, they also synchronize data with others to reduce delay and unavailability to corporate and individual users as much as possible.

For this reason, higher-capacity network interfaces are immediately used in these environments, available on the market, even before they are standardized.

The following table describes the main features of the optical Ethernet interfaces available on the market or under development.

Some of them are standardized by IEEE™ and others are supported by MSAs (***Multi-Source Agreement***).

Data Rate	Interface	Document	Distance (m) OM3 / OM4 / OM5 / SM	Optical Interface (Conector)	Qty. of pairs of fibers	Fiber Wave Lengths
400 Gb/s	400GBASE-SR4.2*	IEEE P802.3cm™*	70 / 100 / 150 / -	MPO8 / MPO12	4	2
	400G BiDi*	400G BiDi Specification (MSA)**	70 / 100 / 150 / -	MPO8 / MPO12	4	2
	400GBASE-SR8*	IEEE P802.3cm™*	70 / 100 / 100 / -	MPO16 / MPO24	8	1
	400GBASE-SR16	IEEE 802.3bs™	70 / 100 / 100 / -	2xMPO16 / MPO32	16	1
	400GBASE-DR4	IEEE 802.3bs™	- / - / - / 500	MPO8 / MPO12	4	1
	400GBASE-FR8	IEEE 802.3bs™	- / - / - / 2k	Duplex LC	1	8
	400GBASE-LR8	IEEE 802.3bs™	- / - / - / 10k	Duplex LC	1	8
200 Gb/s	200GBASE-SR4*	IEEE P802.3cd™	70 / 100 / 100 / -	MPO8 / MPO12	4	1
	200GBASE-DR4	IEEE 802.3bs™	- / - / - / 500	MPO8 / MPO12	4	1
	200GBASE-FR4	IEEE 802.3bs™	- / - / - / 2k	Duplex LC	1	4
	200GBASE-LR4	IEEE 802.3bs™	- / - / - / 10k	Duplex LC	1	4
100 Gb/s	100GBASE-SR10	IEEE 802.3-2015™ Section 6	100 / 150 / - / -	2xMPO12 / MPO24	10	1
	100GBASE-SR2*	IEEE P802.3cd™	70 / 100 / 100 / -	MPO8 / MPO12	2	1
	100GBASE-DR*	IEEE P802.3cd™	- / - / - / 500	Duplex LC	1	1
	100GBASE-SR4*	IEEE 802.3-2015™ Section 6	70 / 100 / - / -	MPO8 / MPO12	4	1
	100GBASE-LR4	IEEE 802.3-2015™ Section 6	- / - / - / 10k	Duplex LC	1	4
	100GBASE-ER4	IEEE 802.3-2015™ Section 6	- / - / - / 30k	Duplex LC	1	4
	100G SWDM4	100G SWDM4 Technical Specifications (MSA)	70 / 100 / 150 / -	Duplex LC	1	4
	100G PSM4	100G PSM4 Technical Specification (MSA)	- / - / - / 500	MPO8 / MPO12	4	1
	100G CLR4	100G CLR4 Technical Specification (MSA)	- / - / - / 2k	Duplex LC	1	1
	100G CWDM4	100G CWDM4 Technical Specifications (MSA)	- / - / - / 2k	Duplex LC	1	1
50 Gb/s	50GBASE-SR*	IEEE P802.3cd™	70 / 100 / 100 / -	Duplex LC	1	4
	50GBASE-FR*	IEEE P802.3cd™	- / - / - / 2k	Duplex LC	1	1
	50GBASE-LR*	IEEE P802.3cd™	- / - / - / 10k	Duplex LC	1	1
40 Gb/s	40G SWDM	40G SWDM4 Technical Specifications (MSA)	240 / 350 / 440 / -	Duplex LC	1	4
	40GBASE-SR4	IEEE 802.3-2015™ Section 6	100 / 150 / - / -	MPO8 / MPO12	4	1
	40GBASE-FR	IEEE 802.3-2015™ Section 6	- / - / - / 2k	Duplex LC	1	1
	40GBASE-LR4	IEEE 802.3-2015™ Section 6	- / - / - / 10k	Duplex LC	1	4
	40GBASE-ER4	IEEE 802.3-2015™ Section 6	- / - / - / 30k	Duplex LC	1	4
25 Gb/s	25GBASE-SR	IEEE 802.3by™	70 / 100/ 100*** / -	Duplex LC	1	1
	25GBASE-LR	IEEE 802.3cc™	- / - / - / 10 k	Duplex LC	1	1
	25GBASE-ER	IEEE 802.3cc™	- / - / - / 30 k	Duplex LC	1	1

(*) Standard under development by IEEE at the time of publication of this document, there may be changes until final publication; (**) Specification under development by MSA at the time of publication of this document, there may be changes until final publication; Optical networks of 10Gb/s and below were not listed.

MSA (MULTI-SOURCE AGREEMENT)

MSAs are joint initiatives of manufacturers to offer alternatives to the networks developed by traditional standardization bodies. Supported by several manufacturers that guarantee their interoperability, several purchase options are available to the user, without the fear of a proprietary solution.

MSAs often offer speeds and connectivity demanded by end users before standards, meeting specific needs and solving problems that have not yet been addressed by regulatory bodies. Examples of MSAs used throughout the network industry are transceivers formats (***SFP***, QSFP, CFP, etc.). Protocol-related MSAs are predominantly associated with Ethernet.

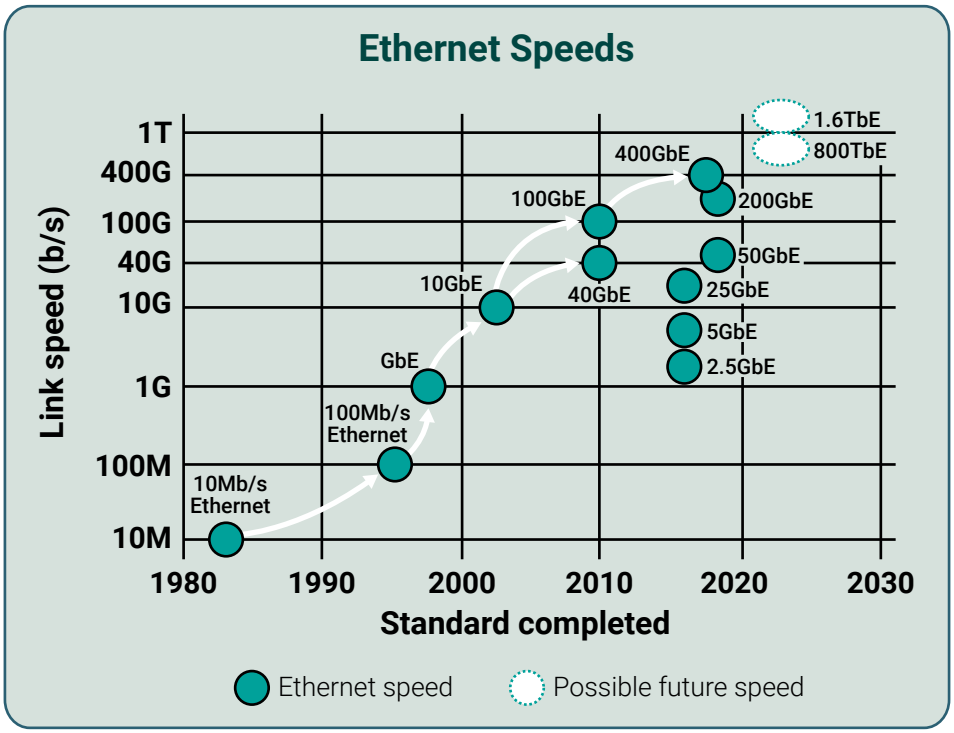
As they are developed by the same companies that manufacture the standardized interfaces, the technical specifications of the MSAs are very similar to those that will be defined by the standardization bodies, being to some extent compatible.

It is important to observe the technical specifications of any MSA that is intended to be used, be sure of the applicability to the required solution.

THE FUTURE OF ETHERNET

The Ethernet Marketplace can be well represented by the Ethernet Alliance, which regularly publishes a ***roadmap*** summarizing what members understand as the future of technology. This view is, in general, corroborated by patterns over time. This alliance includes equipment manufacturers, users and many of the professionals who are defining the standards in the IEEE.

The main highlight is the 400 Gb/s, a speed already available in some media, standardized and in increasing adoption by the market, especially ***hyperscale*** and ***mega-datacenters.***



4.2. Fiber Channel

Most Data Center storage network connections, in many cases known as the ***Storage Area Network*** (SAN), are performed in a ***Fiber Channel***. In some cases, it is managed by a different team than the "LAN" network and even has specific, separate cabling for this segment only. Financial institutions and others seek the robustness and reliability of this protocol to transmit large volumes of data between mass storage systems and servers. Specific switching devices (***Fiber Channel Switches*** or ***Directors***) promote the connection between the elements that use this network.

In general, it is the servers that lie between the two networks (LAN and SAN) and therefore have the ***Ethernet*** and ***Fiber Channel*** interfaces. In one hand, they make the connection to the network that takes and brings information from the Data Center to the cloud and, on the other hand, manages the storage itself in the Data Center.

The main interfaces standardized or under development by Group T of INCITS™ (***International Committee for Information Technology Standards***) are as follows:

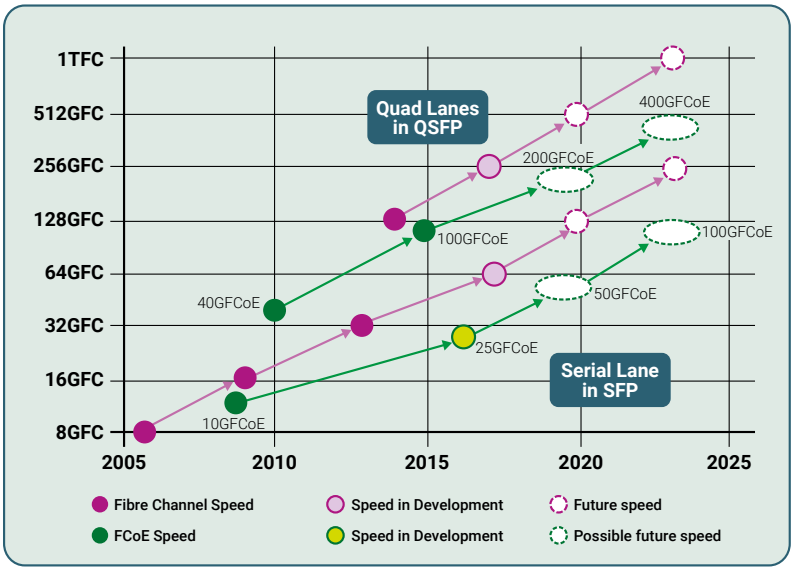
Family	Interface	Document	Distance (m) OM3 / OM4 / OM5 / SM	Optical Interface (Connector)	Qty. of pairs of fibers	Fiber Wave Lengths
256GFC	256GFC-SW4*	FC-PI-7P*	70 / 100 / - / -	MPO8 / MPO12	4	1
	256GFC-PSM4*	FC-PI-7P*	- / - / - / 500	MPO8 / MPO12	4	1
	256GFC-CWDM4*	FC-PI-7P*	- / - / - / 2k	Duplex LC	1	4
128GFC	128GFC-SW4*	FC-PI-6P*	70 / 100 / - / -	MPO8 / MPO12	4	1
	128GFC-PSM4*	FC-PI-6P*	- / - / - / 500	MPO8 / MPO12	4	1
	128GFC-CWDM4*	FC-PI-6P*	- / - / - / 2k	Duplex LC	1	4
64GFC	64GFC-SW*	FC-PI-7*	70 / 100 /100 / -	Duplex LC	1	1
	64GFC-LW*	FC-PI-7*	- / - / - / 10k	Duplex LC	1	1
32GFC	3200-M5F-SN-I	FC-PI-6	- / 100 / - / -	Duplex LC	1	1
	3200-M5E-SN-S	FC-PI-6	70 / - / - / -	Duplex LC	1	1
	3200-SM-LC-L	FC-PI-6	- / - / - / 10k	Duplex LC	1	1
16GFC	1600-M5F-SN-I	FC-PI-5	- / 125 / - / -	Duplex LC	1	1
	1600-M5E-SN-I	FC-PI-5	100 / - / - / -	Duplex LC	1	1
	1600-SM-LZ-I	FC-PI-5	- / - / - / 2k	Duplex LC	1	1
	1600-SM-LC-L	FC-PI-5	- / - / - / 10k	Duplex LC	1	1
8GFC	800-M5F-SN-I	FC-PI-5	- / 190 / - / -	Duplex LC	1	1
	800-M5E-SN-I	FC-PI-5	150 / - / - / -	Duplex LC	1	1
	800-SM-LC-I	FC-PI-5	- / - / - / 1,4kk	Duplex LC	1	1
	800-SM-LC-L	FC-PI-5	- / - / - / 10k	Duplex LC	1	1

(*) Standard under development by INCITS at the time of publication of this document, which may be changed until final publication.

THE FUTURE OF FIBER-CHANNEL

The Fiber Channel ***Roadmap*** is maintained by the FCIA (***Fiber Channel Industry Association***). The latest version of ***Roadmap*** projects the availability of 512GFC and 1TFC by 2025.

In this ***Roadmap*** it can also be observed the evolution of FCoE (***Fiber Channel over Ethernet***), following the ***Ethernet*** speeds. FCoE is a transport alternative for the ***Fiber Channel*** protocol encapsulated in the physical layer of ***Ethernet***, used as a method of universalizing ***Ethernet*** to the entire network (LAN and SAN) of the Data Centers.



4.3. *Infiniband*

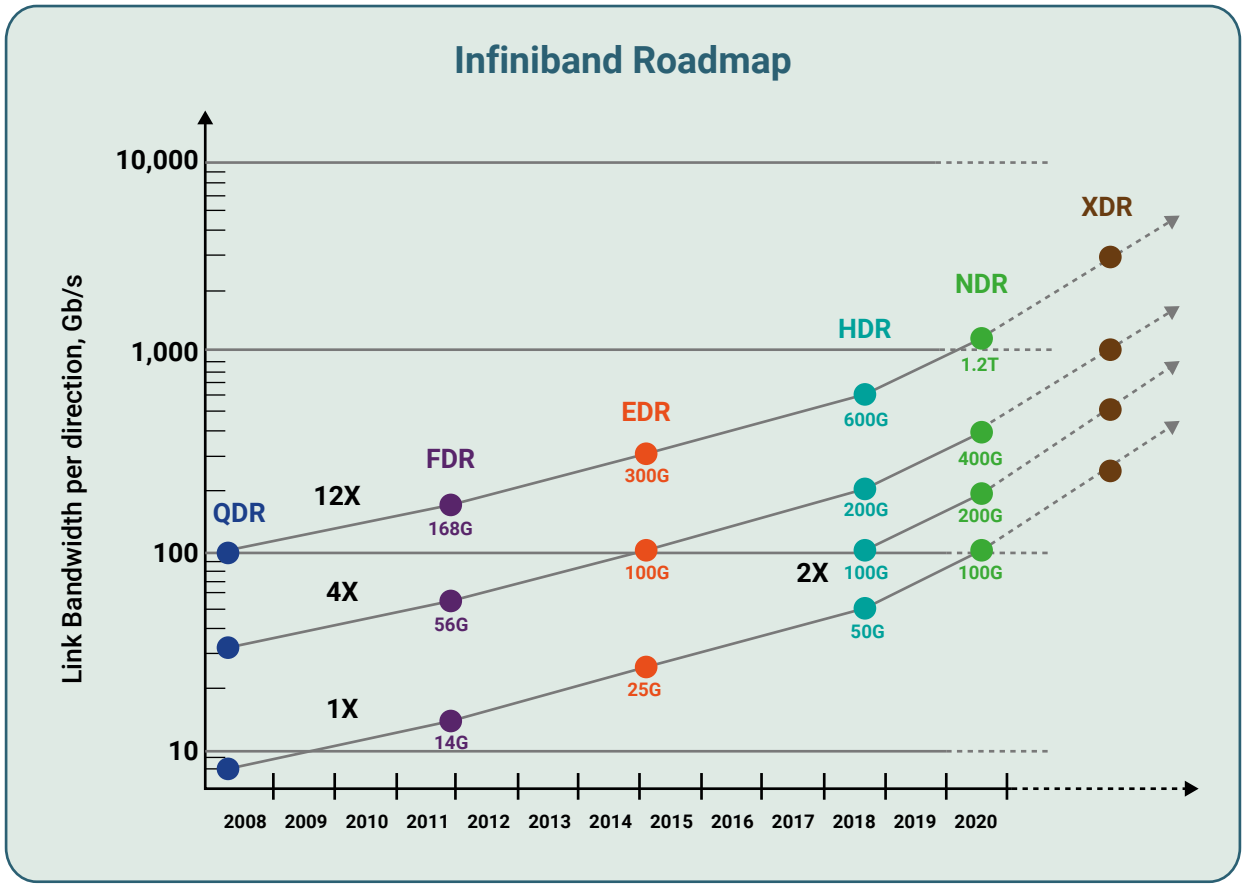
The ***Infiniband*** protocol has features of high transfer capacity and low latency. It is widely used in the interconnection of storage systems in the "SAN" network of Data Centers. It is the main means of connecting supercomputers, also present in this environment.

The InfiniBandSM Trade Association (IBTA) defines and publishes the specifications of this protocol. The interfaces and speeds defined so far are as follows:

Data Rate	Interface	Document	Distance (m) OM3 / OM4 / OM5 / SM	Optical Interface (Connector)	Qty. of pairs of fibers	Fiber Wave Lengths
2,5Gb/s (SDR)	IB-1X-SX	InfiniBand™ Architecture Specification Volume 2 - PHYSICAL SPECIFICATIONS	500 / - / - / -	Duplex LC	1	1
	IB-1x-LX		- / - / - / 10k	Duplex LC	1	1
4x2,5Gb/s (4xSDR)	IB-4X-SX		200 / - / - / -	MPO8 / MPO12	4	1
	IB-4X-SX		- / - / - / 10k	Duplex LC	1	1
8x2,5Gb/s (8xSDR)	IB-8X-SX		200 / - / - / -	2xMPO12	8	1
12x2,5Gb/ s (12xSDR)	IB-12X-SX		200 / - / - / -	2xMPO12	12	1
5Gb/s (DDR)	IB-1X-DDR-SX		200 / - / - / -	Duplex LC	1	1
	IB-1x-DDR-LX		- / - / - / 10k	Duplex LC	1	1
4x5Gb/s (4xDDR)	IB-4X-DDR-SX		150 / - / - / -	MPO8 / MPO12	4	1
8x5Gb/s (8xDDR)	IB-8X-DDR-SX		150 / - / - / -	2xMPO12	8	1
12x5Gb/s (12xDDR)	IB-12X-DDR-SX		150 / - / - / -	2xMPO12	12	1
4x2,5Gb/s (4xSDR)	IB-1X-QDR-SX		300 / - / - / -	Duplex LC	1	1
	IB-1X-QDR-LX		- / - / - / 10k	Duplex LC	1	1

Multimode fibers in this document are referenced only up to OM3 (2000 MHz.km@850 nm), so the distances are designated only for this type. OM4 and OM5 fibers can be used for the same applications with guaranteed minimum distance service specified for OM3. The above specifications are contained in the document valid at the time of editing this guide and may be changed at any time in accordance with the IBTA update program.

Some manufacturers offer systems with support for FDR (14 Gb/s), EDR and HDR. They have their own speeds and specifications, with higher speeds and/or distances, but based on those specified above. In this case, the requirements of the system supplier must be observed. For the future, IBTA forecasts speeds of more than 1 Tb/s by 2020.



5 Getting to know the Data Center Products

A Data Center must be prepared to support current and future data transmission protocols and meet equipment connection topologies, and at the same time enable its growth in a modular and organized manner.

In this chapter, you will learn more about the indispensable components for building a data center and the Furukawa options that will ensure that these requirements are met.

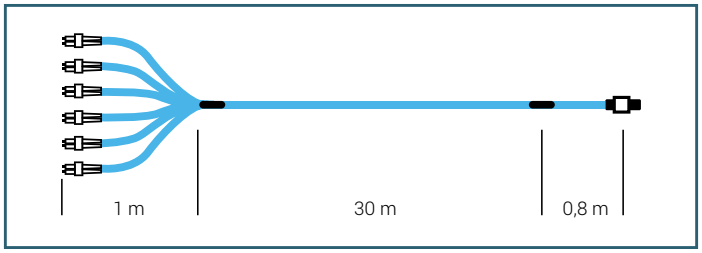
5.1. Optical Cabling

Pre-Terminated Optical Cables

Applicable over longer distances, pre-terminated optical cables provide easier and faster installation in plug-and-play systems with easily expansion and handling.

PREMIUM PRE-TERMINATED TRUNK CABLE 12F

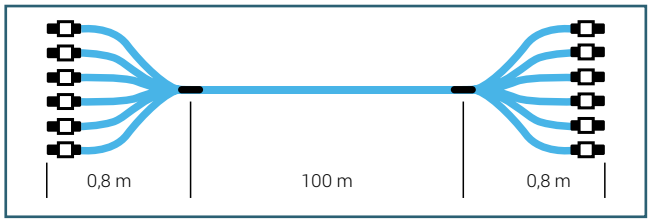
Ex.: ***TRUNK CABLE PRE-TERMINATED FANOUT PREMIUM 12F OM4 LC(UB)-UPC/MPO12-UPC(U) 1.0D2/0.8D3 30.0M - UT - LSZH – AQUA***



- Product with high performance optical components;
- Available with Premium Universal MPO or Uniboot LC connectors;
- The Universal MPO connector allows the field change of the gender (male/female) and polarity (A type/B type) in accordance with the project demand;
- MPO Polishing APC for single mode and UPC for multimode;
- 12 Fibers Optical Cable (SM BLI, OM4 or OM5);
- Nominal external cable diameter 5.5 mm;
- Length from 15 to 200 m;
- Flammability class LSZH IEC 60332-3;
- Factory assembled and tested. The test report can be consulted on the web through the product's serial number.

PREMIUM PRE-TERMINATED TRUNK CABLE 24F TO 144F

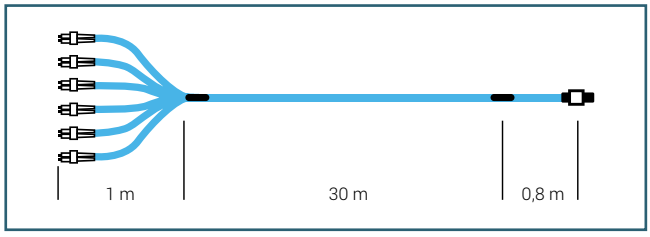
Ex.: ***TRUNK CABLE PRE-TERMINATED PREMIUM 72F OM4 MPO12-UPC(U)/MPO12-UPC(U) 0.8D3/0.8D3 100.0M - TS - LSZH – AQUA***



- Product with high performance optical components;
- Available with Premium Universal MPO or Uniboot LC connectors;
- The Universal MPO connector allows the field change of the gender (male/female) and polarity (A type/B type) in accordance with the project demand;
- MPO Polishing APC for single mode and UPC for multimode;
- Optical cable from 24 to 144 fibers (SM, OM4 or OM5) with 12 fibers MPO connector on each side;
- Length from 15 to 200 m;
- Flammability class LSZH IEC 60332-3;
- Factory assembled and tested. The test report can be consulted on the web through the product's serial number.

PRE-TERMINATED TRUNK CABLE 12F

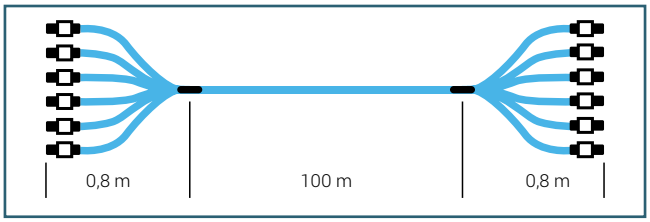
Ex.: ***TRUNK CABLE PRE-TERMINATED FANOUT 12F OM4 LC(UB)-UPC/MPO12-UPC(M/F) 1.0D2/0.8D3 30.0M - UT - LSZH – AQUA***



- Available with standard MPO or LC connectors;
- MPO Polishing APC for single mode and UPC for multimode;
- MPO connector Gender – (M) Male or (F) female;
- 12 fibers Optical cable (SM, OM3, OM4 or OM5);
- Nominal external cable diameter 5.5 mm;
- Length from 15 to 200 m;
- Flammability class LSZH IEC 60332-3;
- Factory assembled and tested. The test report can be consulted on the web through the product's serial number.

PRE-TERMINATED TRUNK CABLE 24F TO 144F

Ex.: ***TRUNK CABLE PRE-TERMINATED 72F OM4 MPO12-UPC(M/F)/MPO12-UPC(M/F) 0.8D3/0.8D3 100.0M - TS - LSZH – AQUA***



- Available with standard MPO or LC connector;
- MPO Polishing APC for single mode and UPC for multimode;
- MPO connector Gender – (M) Male or (F) female;
- Optical cable from 24 to 144 fibers (SM, OM3, OM4) with 12 fibers MPO connector on each side;
- Length from 15 to 200 m;
- Flammability class LSZH IEC 60332-3;
- Factory assembled and tested. The test report can be consulted on the web through the product's serial number.

Products suitable for Maneuvering Areas

DUPLEX OPTICAL PATCH CORD PREMIUM

Ex.: ***DUPLEX OPTICAL PATCH CORD PREMIUM OM4 LC(UB)-UPC/LC(UB)-UPC – 2.5M - LSZH - AQUA (A - B)***

- Product with high performance optical components;
- Multifiber Cordage with 2 fibers (SM BLI, OM4 or OM5);
- Nominal external diameter of 1.6 mm;
- Premium Unitboot LC connectors at both ends;
- Length from 1 to 50 m;
- Flammability class LSZH IEC 60332-3;
- Factory assembled and tested. The test report can be consulted on the web through the product's serial number.

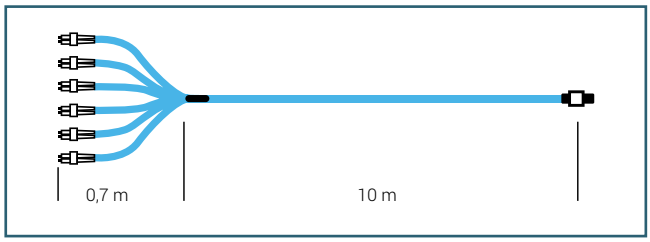
DUPLEX OPTICAL CORD

Ex.: ***DUPLEX OPTICAL PATCH CORD OM3 LC-UPC/LC-UPC 5.0M - LSZH - AQUA (A - B)***

- 2 fibers Zip-Cord Cordage (SM, OM3, OM4 or OM5);
- Length from 1 to 50 m;
- Flammability class LSZH IEC 60332-3.

OPTICAL PATCH CORD FANOUT PREMIUM 12F

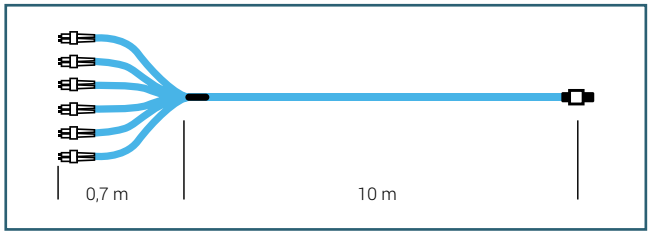
Ex.: ***OPTICAL PATCH CORD FANOUT 12F PREMIUM OM4 LC(UB)-UPC/MPO12-UPC(U) 0.7D2/10.0D3 - MTF - LSZH - AQUA***



- Product with high performance optical components;
- Available with Premium Universal MPO or Uniboot LC connector;
- The Universal MPO connector allows the field change of the gender (male/female) and polarity (A type/B type) in accordance with the project needs;
- 12 fibers Internal multifiber cordage (SM, OM4 or OM5);
- Nominal external diameter of 3.0 mm;
- Length form 1 to 50 m;
- Flammability class LSZH IEC 60332-3;
- Factory assembled and tested. The test report can be consulted on the web through the product's serial number.

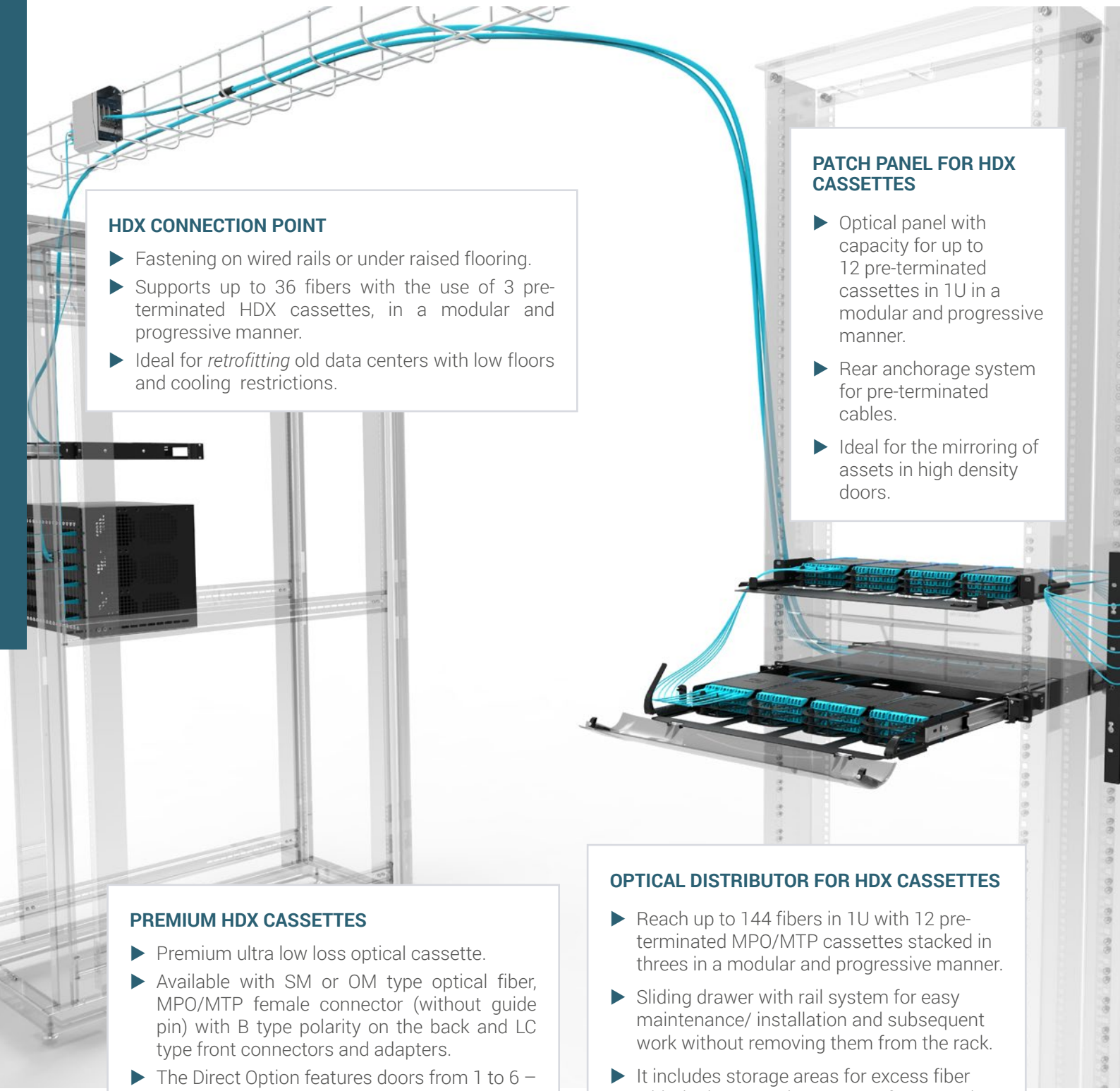
OPTICAL PATCH CORD FANOUT 12F

Ex.: ***OPTICAL PATCH CORD FANOUT 12F OM4 LC-UPC/MPO12-UPC(M/F) 0.7D2/10.0D3 - MTF - LSZH - AQUA***



- Available with standard MPO or LC connector;
- MPO Polishing APC for single mode and UPC for multimode;
- MPO connector Gender – (M) Male or (F) female;
- Fibers Internal multifiber cordage (SM, OM3, OM4);
- Nominal external diameter of 3.0 mm;
- Length form 1 to 50 m;
- Flammability class LSZH IEC 60332-3;
- Factory assembled and tested. The test report can be consulted on the web through the product's serial number.

HDX System



HDX CONNECTION POINT

- Fastening on wired rails or under raised flooring.
- Supports up to 36 fibers with the use of 3 pre-terminated HDX cassettes, in a modular and progressive manner.
- Ideal for *retrofitting* old data centers with low floors and cooling restrictions.

PATCH PANEL FOR HDX CASSETTES

- Optical panel with capacity for up to 12 pre-terminated cassettes in 1U in a modular and progressive manner.
- Rear anchorage system for pre-terminated cables.
- Ideal for the mirroring of assets in high density doors.

PREMIUM HDX CASSETTES

- Premium ultra low loss optical cassette.
- Available with SM or OM type optical fiber, MPO/MTP female connector (without guide pin) with B type polarity on the back and LC type front connectors and adapters.
- The Direct Option features doors from 1 to 6 – from left to right; product in black color.
- The Reverse Option features ports 6 to 1 - from left to right; product in white color.
- Easy instalation, without the need for special tools or mechanical adaptations.

OPTICAL DISTRIBUTOR FOR HDX CASSETTES

- Reach up to 144 fibers in 1U with 12 pre-terminated MPO/MTP cassettes stacked in threes in a modular and progressive manner.
- Sliding drawer with rail system for easy maintenance/ installation and subsequent work without removing them from the rack.
- It includes storage areas for excess fiber with the integrated presence of an organizer that ensures compliance with the radii of curvature of the fibers installed.

5.2. Copper Cabling

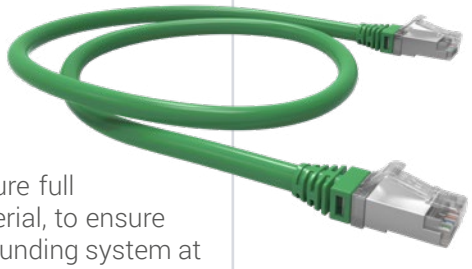
Furukawa offers a complete line of traditional copper cabling. It also offers **sustainable** cables, called **Green line**, produced in green polyethylene, with a low level of smoke emission (LSZH).

Green Line

GIGALAN AUGMENTED GREEN LAN CABLE CAT.6A LSZH

- It has a cover in Green Polyethylene made from sugarcane.
- Sustainable product.
- Halogen-free flame-retardant outer cover with low smoke emission (LSZH).
- Supports transmissions of 100 Mbps, 1 Gbps and 10 Gbps in channels of up to 100 meters.
- Electrical characteristics in high-speed transmissions with typical attenuation values (dB/100m), NEXT (dB), PSNEXT(dB), RL(dB), ACR(dB), PSANEXT (dB) and PSAACRF (dB) for frequencies up to 500 MHz.

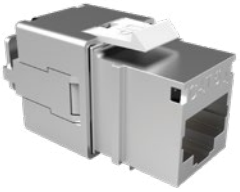
GIGALAN AUGMENTED GREEN PATCH CORD CAT.6A



- It has a cover in Green Polyethylene made from sugarcane.
- Sustainable product.
- Halogen-free flame-retardant outer cover with low smoke emission (LSZH).
- Patch Cord CAT.6A with RJ-45 connectors with double jaws, which ensure full electrical connection with the copper cable and covered by metallic material, to ensure high performance against external noise and interconnection with the grounding system at both ends.

LOW DIAMETER PATCH CORD - 28 AWG

- Over 50% reduction in CAT6A cross-section, providing better airflow.
- High flexibility: Coated conductors with soft, flexible cable jacket provide easy cable management in limited rack spaces and closed cabinets.
- Optimized plug easy access to high-density switch ports.
- ETL Verified for ANSI/TIA Component Level in NEXT and Return Loss.
- Designed to exceed ANSI/TIA NEXT and Return Loss of Component Level values.
- Superior shielding: offers better control of NEXT in CAT version. A.
- Better radius of curvature: 63% improvement in CAT. 6A and 40% in CAT. 6.
- Reduced airflow resistance and better cooling.
- More than 30% weight reduction, generating less stress on the cable and support infrastructure.
- Smooth flexible cable for easy cable management.



GIGALAN AUGMENTED FEMALE CONNECTOR CAT.6A

- Certification LISTED and VERIFIED by third party.
- Contact pathways produced in phosphor bronze with layers of 2.54 µm of nickel and 1.27 µm of gold.

5.3. Complementary Accessories for Infrastructure

ITMAX 19” 45U OPEN RACK

- Option of 2 or 4 columns, supplied with threaded rivet, replacing traditional cage nut.
- Vertical cable manager 200 mm, recommended for end of row and vertical cable manager 315 mm used between racks. Both have plastic “fingers” for better organization of the cables and with radial spools that protect the cables from excessive bending.

SERVER RACK

- Standard 19” rack with drilling ½U for attachment of equipment and accessories.
- Single front door and splitted rear door, both perforated, allowing the correct air flow.
- Front and rear doors with retractable key – ensures the safety of the equipment against unauthorized access.

ITMAX PLASTIC DUCTS

- Products manufactured in thermoplastic, free of halogens.
- Complies with UL94-V0 and UL2024A.
- Wide variety of parts and configurations.

UNLOADED PATCH PANELS

- Made of steel.
- Capacity for 24P in 1U or ½U.
- Flat and angular models for shielded and unshielded solutions.

Designing the Data Center

My challenge is to organize, clearly identifying the participants and coordinators, setting up a timeline for the life of the project. I define each step of the scope, the coordinators and inspectors, who will ensure continuity and final quality.

Cabling Supervisor

6 Projects, Deployment and Certification

After the identification of current and future requirements, definition of topologies and architectures that will be applied in the Data Center and choice of cabling components to be used, it must be ensured that the project is carried out in accordance with the Standards, that the implementation is well done and that the infrastructure is certified for its performance. There's no point in using the best products in a project that doesn't meet standards or is badly installed.

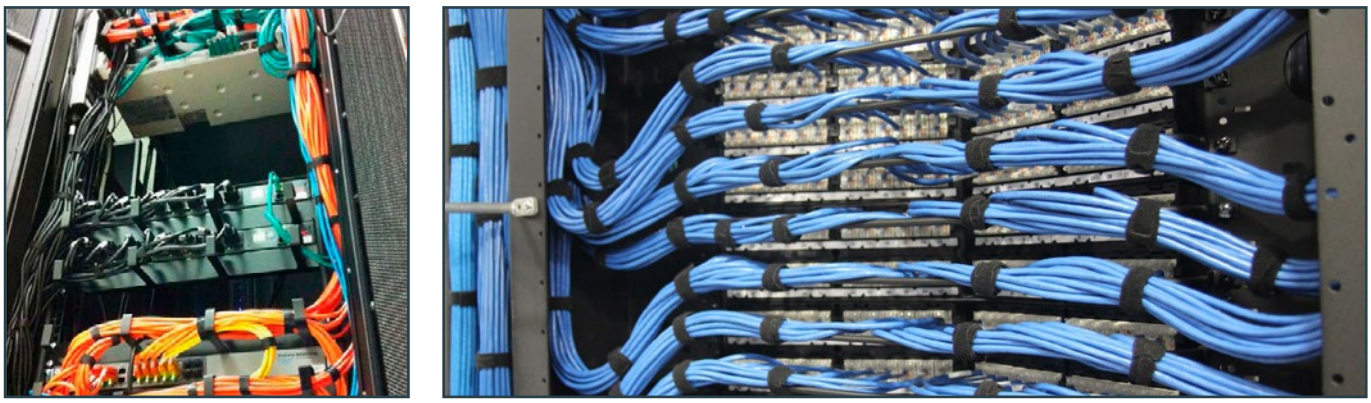
It is also important that the implementation is organized with clear identification of the main participants and coordinated by a schedule during the life of the project – with information from those responsible for each stage of the scope and who will be the coordinators and inspectors who will ensure, respectively, the continuity of the project and its final quality.

In this scenario, an important role is played by the **Cabling Supervisor**, a central figure in the cabling installation, who acts as a bridge between the client, the designer, the supervision and the general coordination of the work. In addition, they should have an overview of the cabling project and its interfaces with other competencies (energy, civil, air conditioning etc.). This professional will be present all the time at the work site and should have a minimum training to manage the implementation process.

Considerations will be presented in this topic to execute the infrastructure project, as well as to perform the implementation and certification of this infrastructure to ensure excellence in its performance.

6.1. Infrastructure Project Considerations

To optimize the use of space in data centers, the density of equipment and cabling infrastructure is steadily increasing. We find examples in MDA, HDA and IDA – where the number of devices and connectivity are extremely high. In addition to this need, we have all the performance requirements. As such, the use of an **optical cabling** has become more common, as its design constitution already has advantages of physical space optimization.



Different environments that require components with different capacities (density).

In the previous chapter, the products of the TeraLan optical line and the HDX system were presented - to high optical point density – in addition to a range of high-performance pre-terminated optical cables with up to 144 fibers – and optical cords that facilitate maneuvering in these areas of high concentration of stitches. In copper cabling, were presented the ***patch panels*** flat and angular that occupy half a ***rack*** unit (1/2 U) and provide 24 ports per ***patch panel***, allowing to obtain up to 48 copper ports per ***rack*** unit.

6.2. Standards for Physical Infrastructure

The following Standards define the routing infrastructure for the structured cabling system and Data Centers.

Due to sustainability assumptions, highlighted in the ANSI/TIA-942-B Standard, it is highly recommended that appropriate products are applied at this stage of the project. For this purpose, Furukawa offers plastic conduits for the optical part of the structured cabling. The ITMAX plastic conduit system is a solution for easy implementation and future expansion, reducing the time spent on installation. Composed of four (100 mm, 220 mm, 300 mm, 600mm) different dimensions, it gives versatility to each proposed project. The entire system was designed in agreement with ANSI/TIA-569-D (***Telecommunications Pathways and Spaces***) and NBR 16415 (***Paths and Spaces for Structured Cabling)***, ensuring the accommodation of the cabling, respecting the radius of curvature and good installation practices.

Manufactured in high-strength plastic material, halogen-free UL94V-0, with protection that guarantees the long life of the color and is UL Listed certified, ensuring compliance with the UL 2024 Standard (***Standard for Cable Routing Assemblies and Communications Raceways***).

It is important to pay attention to the normative occupation rate limits, according to ANSI/TIA-569-D. It is recommended to start the occupation of the infrastructure with a maximum of 25% and, during the useful life, to reach 50% cable occupation.

The Brazilian Standard NBR-16415 limits the rate to 40% maximum occupancy.

Tray with 50% occupancy.

6.3. Project Key Points

The most appropriate way to build a high-speed Ethernet or SAN network for Data Center will depend on: a) the type of topology chosen; b) distances involved; c) transmission speeds; and d) the types of equipment interfaces that will be available.

Below you will find a list of key points, which will help clients and designers in the execution of ***site*** surveys and also in the preparation of premises for the preliminary technical study of structured cabling project for Data Centers.

1. What type of project?
2. Which documents should be observed/followed?
3. What are the dimensions of the Data Center?
4. What are the component environments of the Data Center?
5. On racks and cabinets
6. Network architecture/topology
7. Connectivity
8. Structured cabling
9. Path infrastructure

When receiving a request such as RAFI, RFP or RFQ, what can be delivered to the client?

- Single Line Diagram.
- ***Bill of Materials*** (BoM).
- Rack Bayface.
- ***Layout*** or Plan with ***Grid*** of the raised floor of the Server Room, coordinated by letters and numbers to position and identify ***racks***, ***cabling***, energy, air conditioning etc.
- Polarity analysis of the optical channels.
- Calculation Records (Optical Loss Budget = IL or ***Insertion Loss***).
- ***Product*** Spec-in.
- Technical Specification of Products.
- UL, ETL, CE, CPR, ANATEL certifications.

ATTENTION: The Preliminary Technical Study does not dispense the preparation of an Executive Project. Regarding the project steps to be observed, according to the ANSI/TIA-942-B standard, Chapter 4, it is recommended to follow the steps below to support the preparation of proposed Preliminary Technical Project Studies.

Using Category 8

Regarding the convergence of existing cabling technologies, we can cite Category 8 as a complement to 25/40 Gbps network cabling.

The category specifies minimum requirements for cabling and components 100 Ω CAT 8, Shielded F/UTP or X/FTP (F/FTP or S/FTP), 22 to 24 AWG, 4 pairs, RJ-45 Connector (8-pin), 2 GHz operating frequency. This data transmission categoryis based on the application and cabling standards as shown below:

IEEE	IEEE 802.3bq 25G/40GBASE-T
TIA	ANSI/TIA-568-C.2-1 Category 8 Cabling Soon to be part of ANSI/TIA-568.2-D
ISO International Organization for Standardization	ISO/IEC 11803-1 Generic Cabling Including Class I & II Channels

COMPATIBILITY AND INTEROPERABILITY TABLE:

Modular Plug & Cord Performance	Modular Connection Hardware Performance Category					
	CAT.3	CAT.5e	CAT.6	CAT.6A	CAT.8
CAT.3	CAT.3	CAT.3	CAT.3	CAT.3	CAT.3
CAT.5e	CAT.3	CAT.5e	CAT.5e	CAT.5e	CAT.5e
CAT.6	CAT.3	CAT.5e	CAT.6	CAT.6	CAT.6
CAT.6A	CAT.3	CAT.5e	CAT.6	CAT.6A	CAT.6A
CAT.8	CAT.3	CAT.5e	CAT.6	CAT.6A	CAT.8

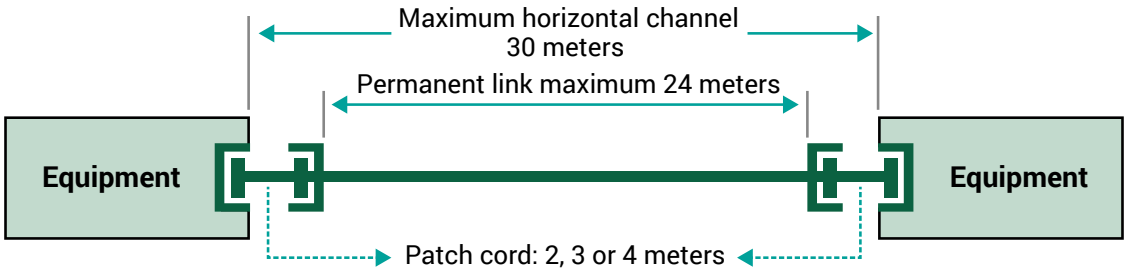
EQUIVALENCE BETWEEN ANSI/TIA AND ISO/IEC:

	TIA	ISO 11801	
Channel / Perm. Link	Cat.8	Class I (DRAFT)	Class II (DRAFT)
Max. Frequency	2000 MHz		
Components	Cat.8	Cat.8.1	Cat.8.2
Extrapolated from	Cat.6A ← (equivalent) →	Class E_A	Class F_A
Style	RJ45		**Non**-RJ45 (TERA, GG45, ARJ45,....)
Field Test Standard	TIA 1152a	IEC 61935-1 Ed.5 (DRAFT)	
… Accuracy Level	2G	Level VI for Cl.I	Level VI for Cl.II

Bicsi

We use Category 8 cabling in 40GBASE-T and 25GBASE-T applications focused on Data Center. There is compatibility with previous categories (RJ-45), but with the restriction of only one channel with two connections. The maximum length of the channel is 30 m, considering the following ***patch cords***:

Conductor gauge or diameter (Copper)	Maximum Patch Cord Length
22 / 23AWG	8 m
24AWG	6 m
26AWG	4 m



6.4. Optical Fiber Cabling Projects

This is a very important point, especially for high speed applications 10/40/100/200/400 Gbps. The optical power loss calculation serves to determine if the designed optical link will meet the requirements of the current applications intended by the project and future applications that may run in this cabling.

The Maximum Optical Attenuation (or ***Insertion Loss***) parameter is critical for data center optical channel design because it defines the proposed optical network topology and whether the physical components are ideal for the project. In case of change, it is estimated the exchange of physical components of termination and connection, optical cables, type of optical fiber used, as well as the infrastructure for routing this wiring and/or their respective physical arrangement of components of the channel.

The following shows the optical channel's IL (dB) notation and calculation routine, according to ANSI/TIA-568-3.D, Item 7.3.7. Attenuation of the Optical Channel, with direct application in the field and that can help both network analysts – focusing on active equipment and/or high-speed optical interfaces (***Transceivers***) – as well as infrastructure analysts for maintenance situations and certification of network cabling. It also assists designers in designing links to new or expanding existing high-speed optical networks in existing data centers and network installers in certification.

Cable Attenuation Provisioning (dB)	Cable Attenuation Coefficient (dB/km) × Link Length (km)
Connector Junction Attenuation Provisioning due to Insertion Loss (dB)	Number of Connector Pair Joints × Loss due to Connector Junction Insertion (dB)
Provisioning for Loss Attenuation in Splices (joins) (dB)	Number of Splices (joins) × Splice (joint) Attenuation (dB)
Attenuation Provisioning of Signal Division components (splitters) (Considering the In/Out Connectors)	Splitter IL loss (dB) (for MPO Cassette to consider IL (dB) of In/Out connectors)
Optical Channel General Attenuation Provisioning (dB)	XX (dB)

Typical values for each cabling element can be found in the supplier's technical specification documents. For application parameters see ANSI/TIA-568-0.D.

Deploying the Data Center

My challenge is to bridge the gap between the client, the designer and the general coordination of the work. I must have an overview of the project and its interfaces with other competencies, such as energy, air conditioning etc.

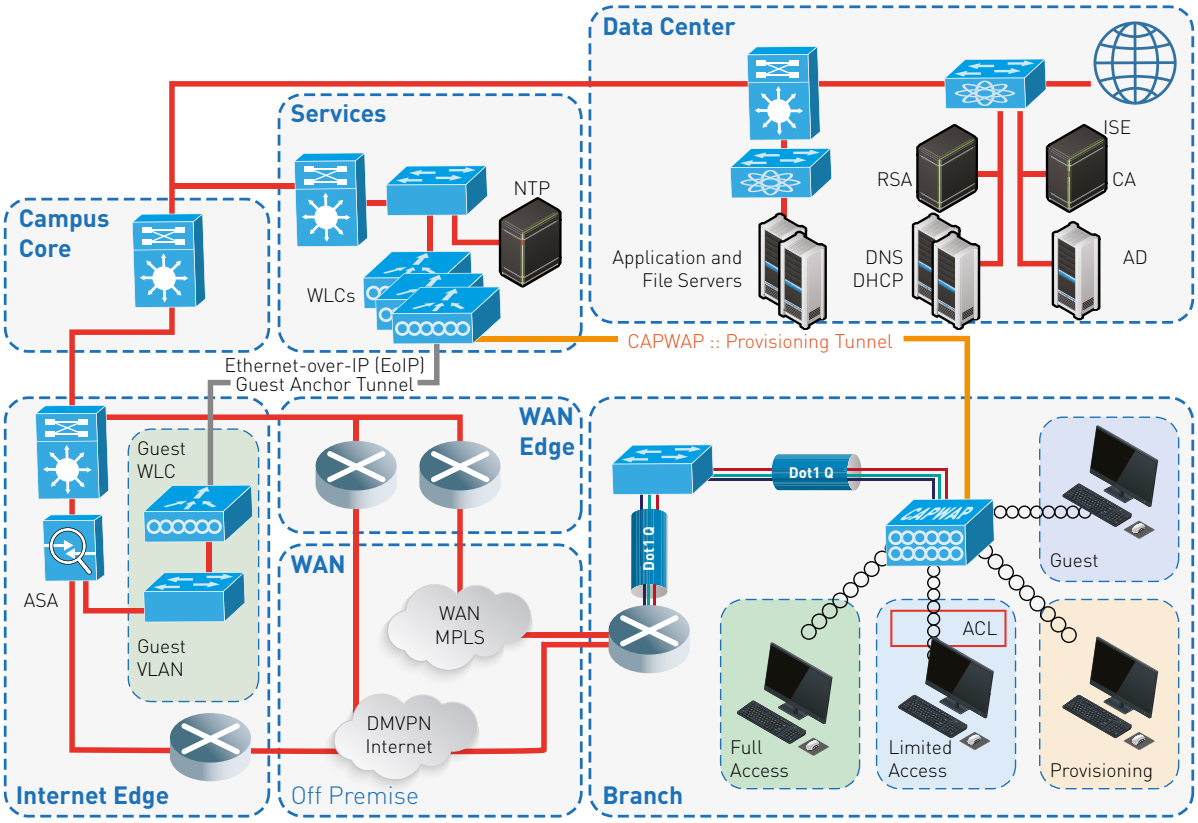
Cabling Supervisor

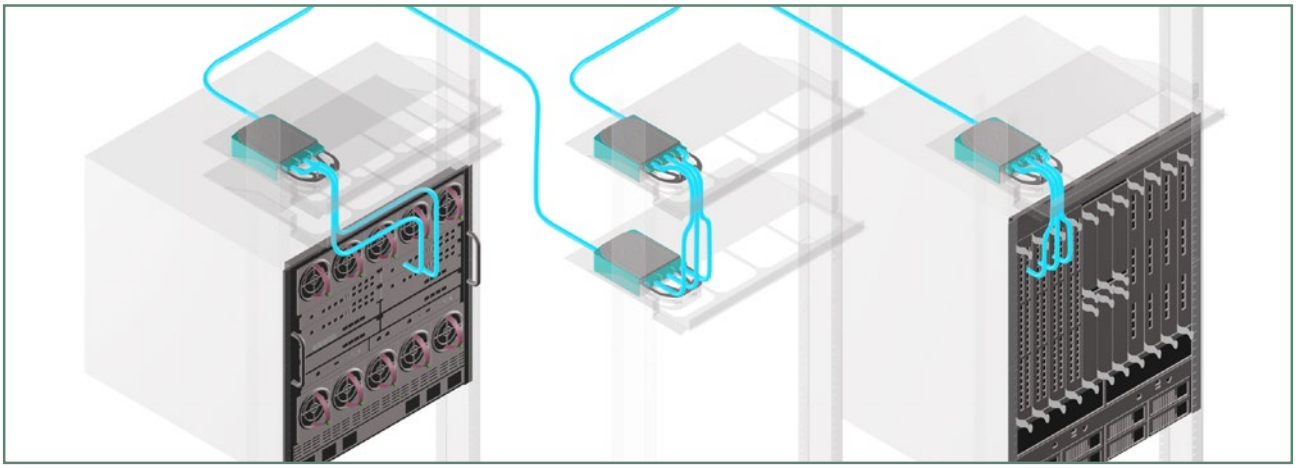
Best Practices

Based on the documentation prepared by the server, storage and network teams, the cabling infrastructure team will be able to analyze the project, checking with the civil construction, architecture, electrical, air conditioning and cable routing infrastructure projects (beds, gutters, conduits), the best way to meet the requested connections, building the network cabling, within the standards and supporting current and future network technologies.

It is always recommended that any installation be anticipated by planning based on Low Level network diagrams, which can be obtained from the client's network team. An example is given below:

LOW-LEVEL DIAGRAM





Cleanliness of Optical Connectivity

In environments with high criticality levels, such as a Data Center, a single connection can compromise the functioning of the entire system. The optical channels depend directly on the quality of the connectivity employed.

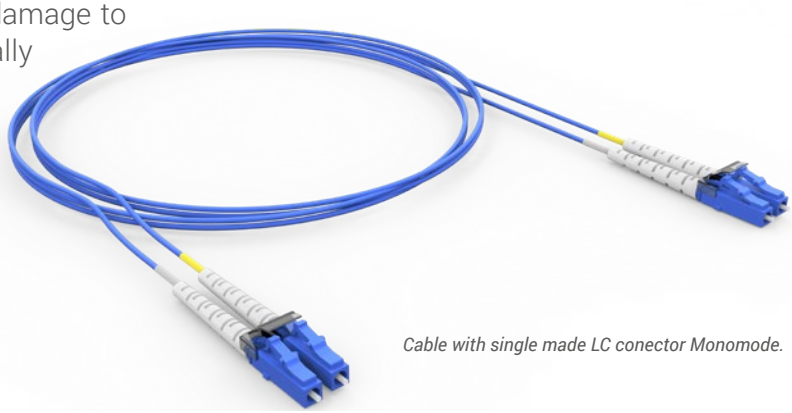
The IEC 61300-3-35:2015 Standard, used as a reference between client and supplier, defines a set of quality requirements for the faces of optical connectors and is designed to ensure insertion loss and return loss performance. If the problem is in a multi-fiber connection, we will have six channels affected.

Standards for 40/100/200/400G transmissions or Fiber ***Channel*** systems determine maximum ***link*** losses to ensure perfect signal transmission. Both models basically require three factors for an excellent optical connection: fiber core alignment, physical contact between the connectors, and ferrule interface.

Fiber core alignment and connector interface are mainly influenced by factors determined in the production line, during the connectorization and polishing of the ferrule surface, associated with the use of quality optical adapters. Fortunately, today's production techniques have almost eliminated all problems with surface alignment and polishing.

Therefore, in general, what determines a bad connection is the quality of the physical contact between the ferrule surfaces of the optical connectors provided during installation. The main problem encountered in the field is the lack of cleaning of the connectors before making the connection. A single particle between the fiber cores can cause significant losses in IL, RL and even equipment damage.

Some particles can cause permanent damage to the ferrule surfaces. The problem is usually detected after the damage has been caused. However, prevention is very simple and can be done quickly by cleaning the ferrules before each connection.

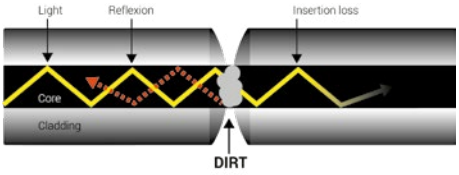


Cable with single made LC conector Monomode.

Core of a single-mode LC Connector.

DIRT

Common types of contamination and defects include the following:



Dust

Fingerprint

Scratches

Contaminants can be found anywhere during the installation and activation of an optical network: in the air, hands, clothing, adapters, ferrule protectors, test equipment etc.

The average size of dust particles is 2-5 µm, not visible to the human eye, and a single grain of dust can be a major problem when incorporated on or near the fiber core. It is important to note that even a new connector can be dirty. Therefore, before any connection, it is necessary to perform the cleaning of the optical elements.

Cleaning can be carried out by means of various special tools or cloths suitable for this purpose.

- **Dry**: by using suitable tools available on the market.
- **Wet**: through the use of suitable tools and isopropyl alcohol.

Work Order Issue

Recommendation for starting cable installation activities:

- Executive project available at the site.
- Understanding the project that will be executed, in relation to the solution that will be applied.
- *Check-list* of materials - whether it is as specified in the project.

On-site inspection:

- Identifying critical points (probable sources of noise), and taking preventive action, informing the designer person responsible for the work, in order to apply the appropriate solution.
- Telecom Room: check sources of moisture, if there are no chemicals or storage of materials other than those of the intended activity.
- Infrastructure: if it is in accordance with the project, with finishing, ground connection, sizing of cable trays and ducts.
- Distance of points: check that it does not exceed 90.0 m of horizontal copper cabling.
- The existence of points in outdoor environments.
- The existence of aggressive or humid environments.
- Proximity to electromagnetic interference (EMI) sources.

Housing the Cables

It is recommended to observe the accommodation of the cables in the infrastructure, based on the type of cable being installed and, in its order of exit - whether from the infrastructure for ***racks***, or to consolidation points or some other infrastructure and always adapting the direction, whether perpendicular, vertical or electrical trays for conduits.

It is important to note in the project, the constant use of all infrastructure accessories for perfect accommodation and preservation of the cables during the launch, such as: curves with adequate radius of curvature, connection accessories, termination and derivation.

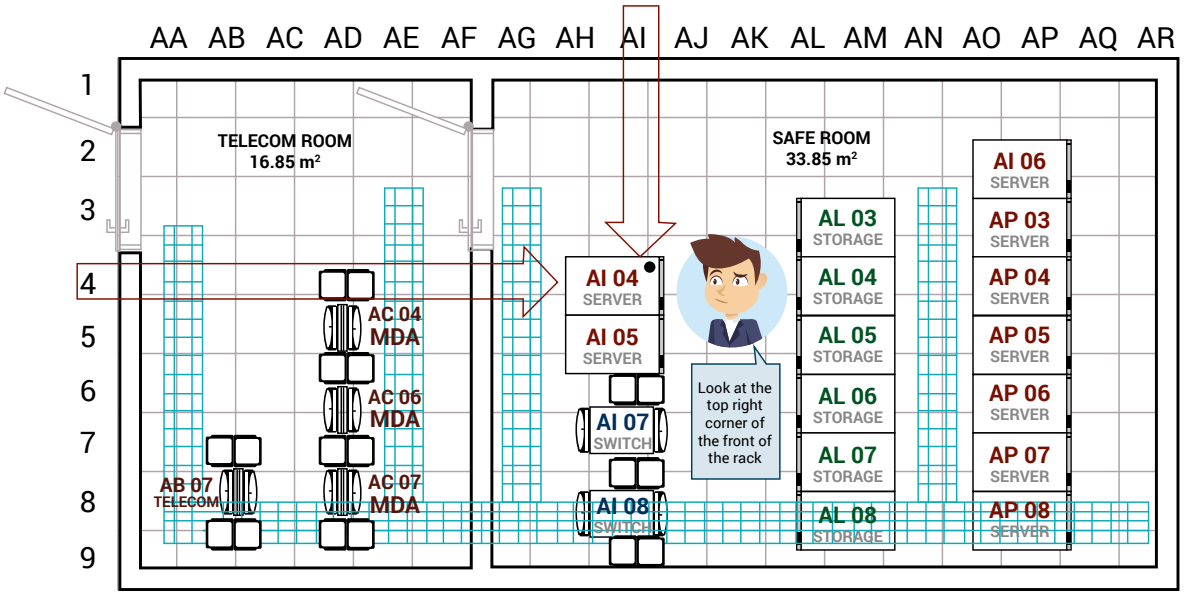
Organization and Identification of the Cables

The main point of cable organization problems today is high-density *racks*. When the maneuvering area is properly organized, all the high-performance electronic and optical characteristics of the channels are maintained.

It is recommended the use of the complete line of accessories and Furukawa horizontal and vertical cable managers in addition to the components that help the installer to organize the cabling in the *rack*. The new ultra-thin 28AWG *patch cord*, diameter < 5 mm (minimum diameter 4.7 mm), available up to CAT.6A, contribute to a better organization of high-density *racks*. They do not compromise identification and optimize cooling, in racks and cabinets, where concentrator *switches* and other high-density network assets are mounted on 1/10/25/40 Gbps network ports without loss of performance.

Another point in the cable organization problems is the identification labels of the SCE (Structured Cabling System). This point is guided by the ANSI/TIA-606-C Standard (June/2017), which recommends starting this process during the project stage.

For Data Center the most recommended is, during the preparation of the server room floor plan, to observe the raised floor, identify the *racks* and cabinets in a matrix format.



The identification of the *rack* will be its position in relation to the *grid* of the raised floor identified in coordinates. For example:

I04

Server rack positioned floor coordinates AI-04.

For *patch panels* and IOPs, the *rack* unit numbers available on products in the 19" mounting plan must be used for both ITMAX and Enterprise open racks, and for closed *racks*.

AI0440

AI04 Rack Patch Panel 40 - The patch panel is at the 40U position of the AI04 Rack.

Finally, for network points, both for outlets in flush mounted or overlapping boxes, as well as in consolidation points or ZDA, and in HDA, IDA, MDA centralizations, it is recommended to identify the network optical or metallic (twisted copper pair) cable on both ends, including patch cords on both ends (patch panel/equipment) and the network outlets of the panels from 1 to 24 only. This prevents lengthy numbering:

AI044021

Point 21 of patch panel 40 mounted on AI04 rack.

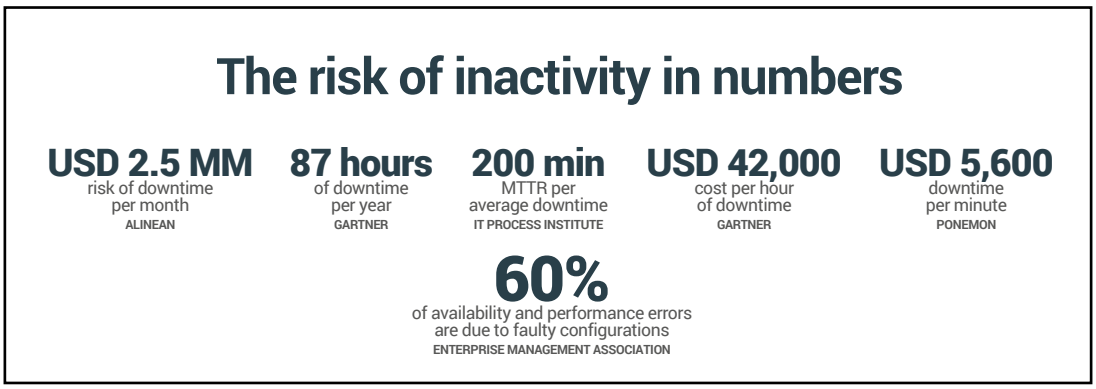
Network Certification

The certification of the network, serves to ensure based on documentation, that the performance parameters of the structured cabling, are in accordance with the current standard chosen as the basis of the project.

In addition to the test report of all certified points, other advantages can be verified with certification:

- In accordance with applicable national and international standards.
- Good design and installation practices of the manufacturer have been followed.
- Applied materials are manufactured by the same supplier.
- The materials have not been counterfeited
- The contracted integrator is recognized by the manufacturer and is up to date with their training.

The following are some market data for the 2017/2018 biennium on Downtime and Disaster & Recovery:



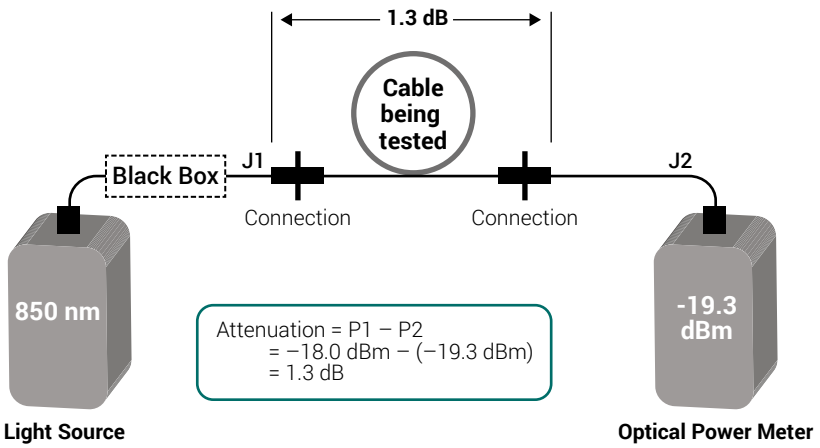
Optical Channel Certification

Measurements on optical channels according to ANSI/TIA-568-3.D, Annex E are: Laboratory ("*Component Level*") and/or Field. Basically, two devices are used for optical measurements: *Power Meter* - Tier 1 (*OLTS - Optical Loss Test Set*) and OTDR - *Optical Time Domain Reflectometer* - Tier 2.

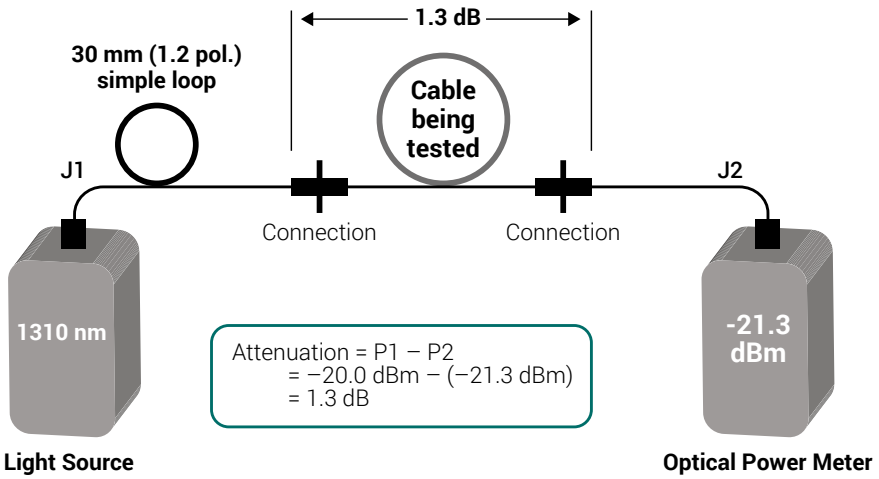
POWER METER - TIER 1

Suitable for SM and MM optical channels where attenuation due to insertion losses are measured against a reliable light source at standardized wavelengths and with a calibrated measuring instrument.

MULTIMODE CHANNELS (MM) - MEASURED AT 850 NM IN BOTH DIRECTIONS ONLY

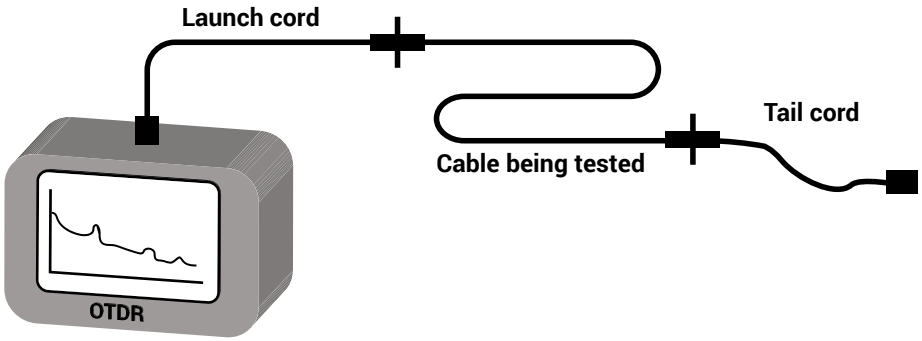


SINGLE MODE CHANNELS (SM) - MEASURED AT 1310 NM AND 1550 NM IN BOTH DIRECTIONS

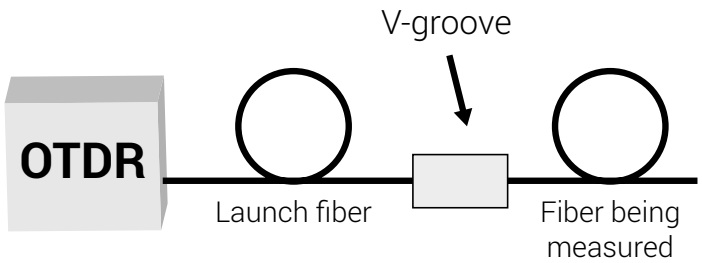


OTDR - TIER 2

Indicated to identify the physical location in meters of the 'optical attenuation events' of the installed optical fiber channel, such as: connections, mergers, fiber curvatures. OTDR offers an indirect measurement of the channel *Insertion Loss*, but it must be compared with the *Power Meter* measurement, among others:



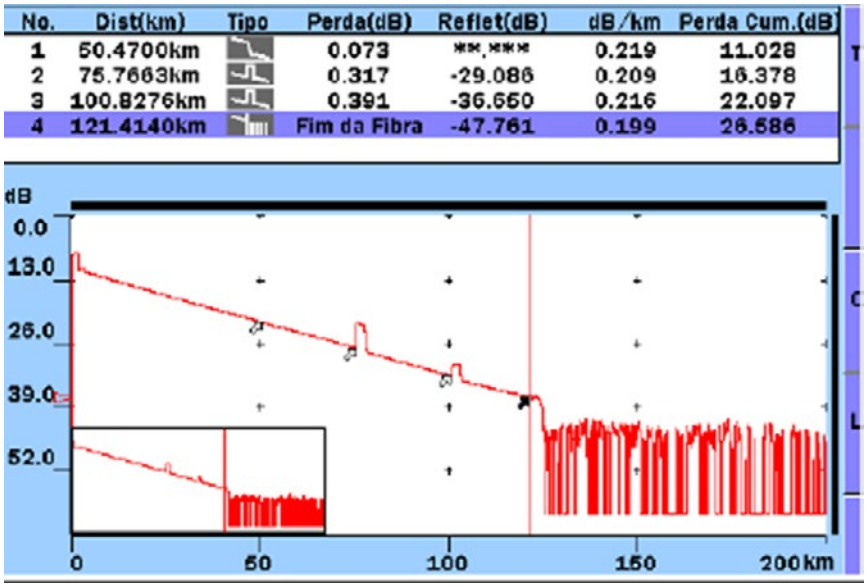
For measurements on optical cable reel for acceptance on-site, for example, use the diagram below:



- Check the equipment manufacturer's user manual.
- Follow the calibration and measurement recommendations.
- Unrated equipment cannot be used for Extended Warranty.

TEST REPORT

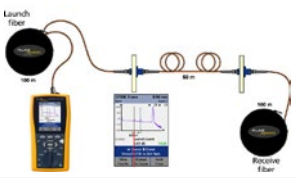
- DTX Standard (Power Meter).
- Displays the attenuation parameters in the two windows MM (850 nm) and SM (1310 nm and 1550 nm).
- Graphics are optional - facilitate visualization of the margin proposed by the manufacturer.
- Compulsory mitigation results.
- OTDR standard.
- Displays the attenuation parameters in the two windows.
- Graphics are mandatory - they allow viewing of the events that caused attenuation and their position on the cable - approximate distance of the light source.
- The curve recording the attenuation events is also mandatory.



EXFO - OTDR Report

TESTING METHODOLOGY

According to current standards, we present the recommended field test methodologies below:

Standard	Method	
ANSI/TIA	ANSI/TIA-568-3.D	
	Tier 1	Tier 2
ISO / IEC	ISO 11801 AMD.1 & ISO/IEC 1476-3	
	Basic Test	Extended Test
	LSPM: Light Source & Power Meter 	OTDR: Optical Time Domain Reflectometer 
Compulsory Item	Field Polarity Test with VFL	

For optical channel testing in mission-critical (Data Center) environments, Furukawa evaluates - in addition to the executive project of the optical link system and all the conditions of installation, assembly, technical certification of the design and installation team - the polarity of the optical system, as a means of certification the functionality of the optical network and its performance response according to attenuation parameters (IL[dB]) x Application (ETH or FC Network Speed) to consider extended warranty contracts. Therefore, the two levels of testing are required.

PERFORMANCE PARAMETERS

The parameters of the ISO/IEC Standard were adopted for this analysis. The following also comply with ANSI/TIA Standards:

- ISO / IEC 11801 prescribes the only performance parameter for field testing of fiber *links*, with *link* attenuation (alternative and equivalent term: insertion loss), when there is the installation of components compatible with this standard.
- For the example cited, the *link* to the attenuation should be calculated according to the specifications within these / IEC 11801. These specifications are obtained from the following formulas:
- *Link* Attenuation = Cable Attenuation + Connector Attenuation + Splice (Join) Attenuation.
- Cable Attenuation (dB) = Cable Attenuation Coefficient (dB/km) × *Link* Length (km).

The values for the attenuation coefficient of the cable are listed in the following table:

Optical Fiber	λ (nm)	Attenuation Coefficient (dB/km)	λ (nm)	Attenuation Coefficient (dB/km)
Multimode 62.5 / 125 µm	850	3.0	1300	1.5
Multimode 50 / 125 µm	850	3.0	1300	1.5
Monomode 9 / 125 µm	1310	1.0	1550	1.0

- Connector Attenuation (dB) = Number of Connector Pairs x Attenuation per Connector (dB).
- Maximum attenuation provision per Connector = 0.75 dB.
- Mend Attenuation (Fusion) (dB) = Number of Splices (Joints) x Attenuation per Splice (Join) (dB).
- Maximum Attenuation Provision per Splice (Join) = 0.3 dB.

Note: link attenuation does not include any active devices or passive devices other than the cable, connectors and splices, that is, link attenuation does not include devices such as optical splitters, couplers, repeaters or optical amplifiers.

The attenuation limit test is based on the use of the '*One Jumper*' Reference Method specified by Method 1 of IEC 61280-4-1 for multimode fibers and Method 1 of EN61280-4-2 for single mode fibers or another equivalent method to be defined in the design of the SCE Optical project. The user must follow the procedures established by these standards or application notes to conduct accurate performance testing

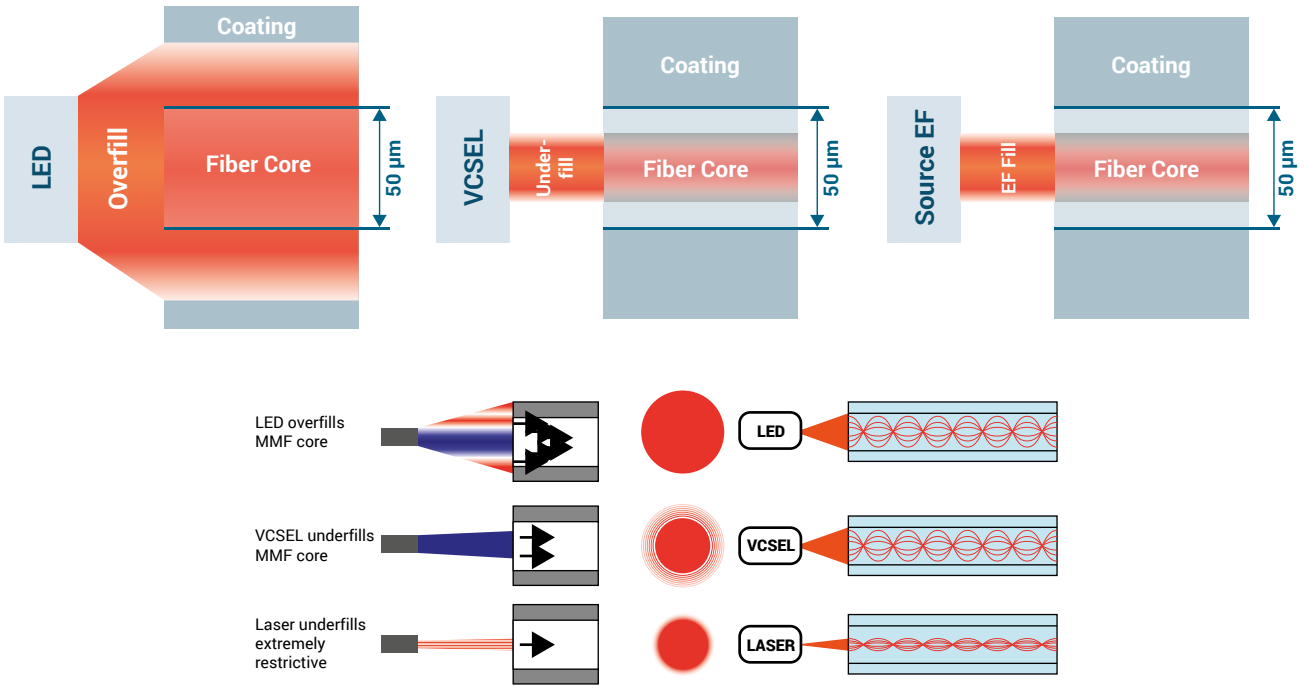
- **MM Horizontal Link (multimode)**: acceptable attenuation connection for an optical fiber cable system. Horizontal multimode is based on the maximum distance of 90 m. The horizontal *link* should be tested at 850 nm and 1300 nm in one direction according to IEC 61280-4-1 method 1, a reference jumper.
- **MM Backbone Links (multimode)**: must be tested at 850 nm and 1300 nm in one direction according to IEC 61280-4-1 method 1. This is due to the length of the *backbone* and the potential number of splices that vary according to site conditions. The *link* attenuation equation (Section 6.4) must be used to determine the limit values (acceptance).
- **SM Backbone Links (single mode)**: must be tested at 1310 nm and 1550 nm according to IEC 61280-4-2, applying the 'One Jumper' Reference Method or the equivalent method. All SM (single mode) *links* must be certified with test tools, using laser light sources at 1310 nm and 1550 nm (see note below).

Note: *Links* to be used with network applications that use laser light sources (the conditions of release underfilled) should be tested with equipment based on laser light sources categorized by *Coupled Power*. Category 2 *ratio* (CPR), *underfilled*, by IEC60825-2. This rule must be followed for cabling systems for support *Gigabit Ethernet* that specifies only the laser light sources. The field test equipment, based on LED (*light emitting diode*), is a category 1 device, according to IEC 60825-2, that normally produces results with high attenuation. Therefore, tests made with these sources are not recommended and will not be accepted.

- **Optional Requirement**: Each optical fiber connection terminated with an optical adapter system that does not impose a direction of transmission shall be tested and documented in both directions, since the direction of signal transmission cannot be predicted at the time of installation.

ENCIRCLED FLUX - EF

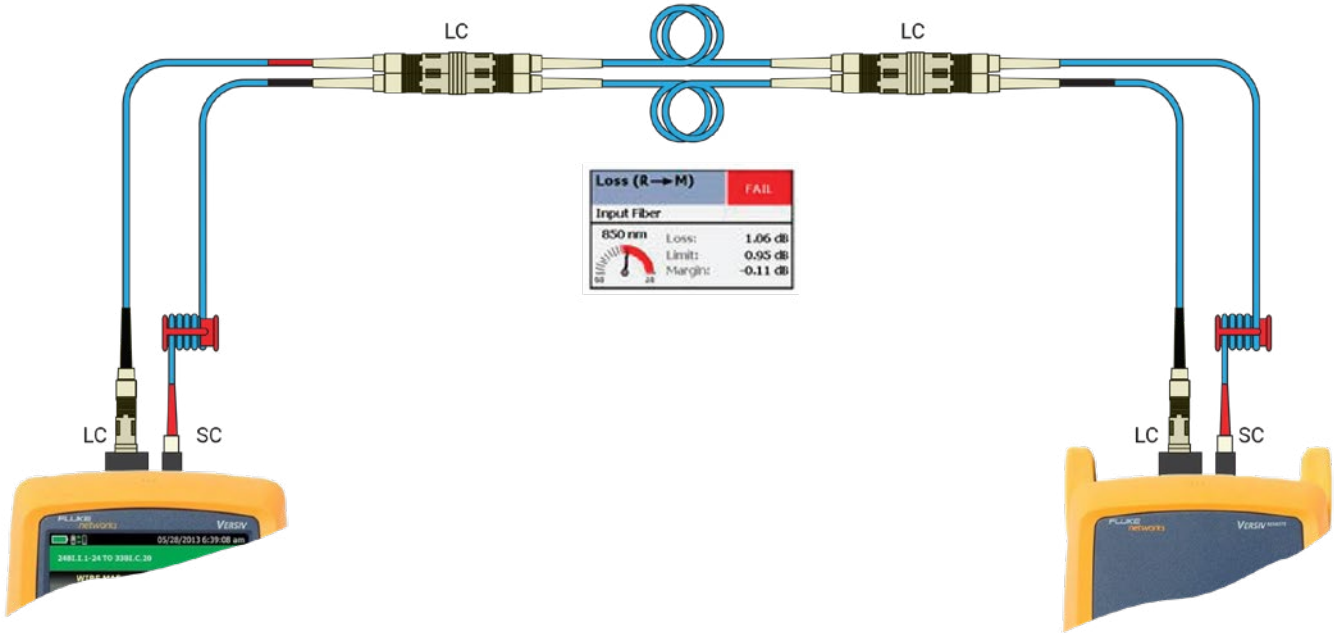
This deals with the repeatability of the IL measurement result on the same optical channel with different OLTS (*Power Meter* + source) test equipment and also as a light controller, which is launched in the MM optical cabling system (50 µm) being tested.



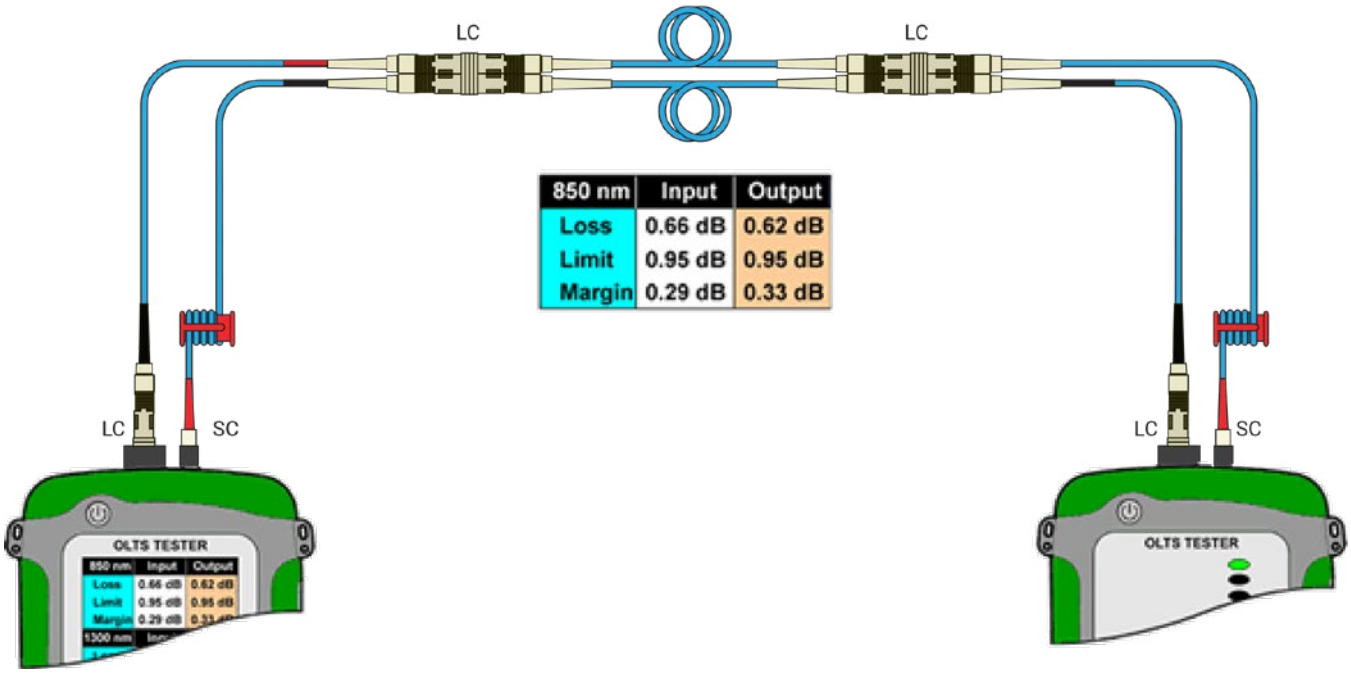
Examples of Light Sources

Different sources will produce different results, even if using the same reference cables and testing the same link. For example:

OLTS 1



OLTS 2



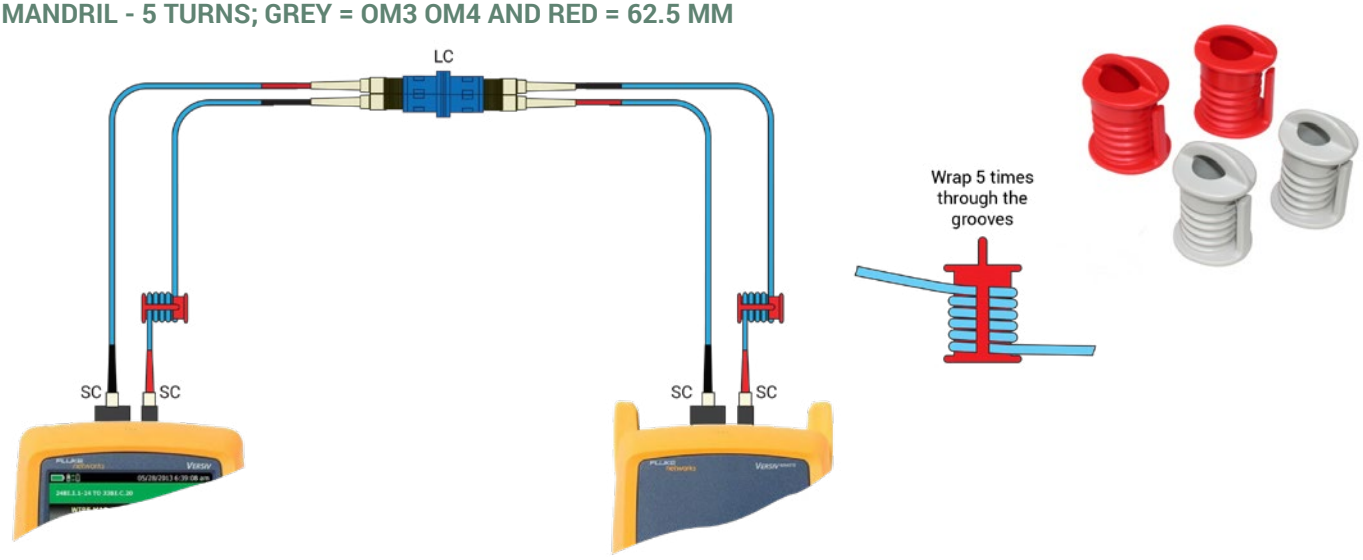
With OLTS 1 registering IL = 1.06 dB and OLTS 2 resulting in IL = 0.66 dB, it can be difficult to know which is correct. For this reason, ANSI/TIA and ISO/IEC have collaborated in the creation of a standard that is to set the launch from a multi-mode source.

This controlled release is called "*Encircled Flux*". Until recently, the only compatible solution with *Encircled Flux* was to use bulky and expensive launch conditioners, like the Mandril.

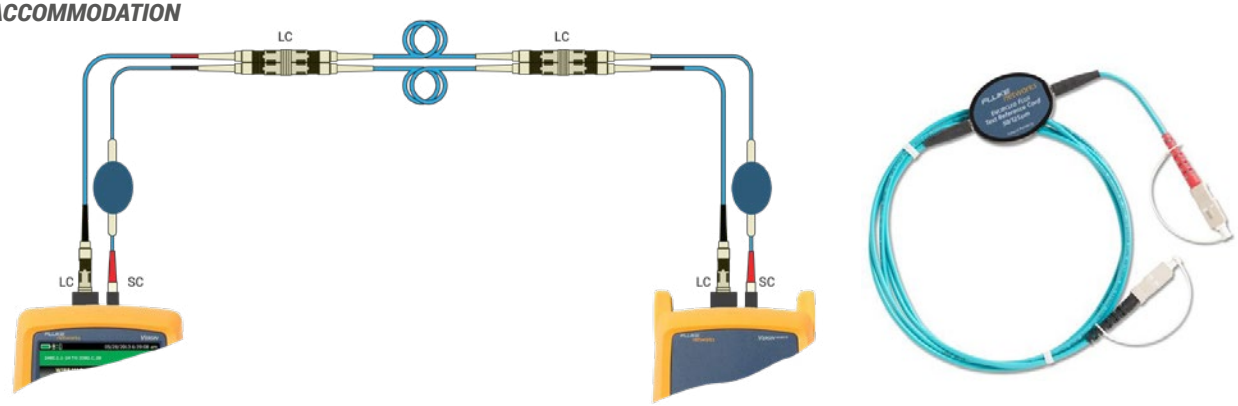
Today there are more advanced flow accommodation modules.

HOW TO CONTROL IT

MANDRIL - 5 TURNS; GREY = OM3 OM4 AND RED = 62.5 MM



FLOW ACCOMMODATION



CERTIFICATION TEST RESULT DOCUMENTATION

The information of the test results for each link shall be stored in the memory of the field test equipment, after completion with the same identifier as the optical link or optical fiber analyzed, and may be sequential or not, but inviolably.

It must be ensured that these results are transferred to the PC unchanged in "native" format, ie, "as stored in test equipment" at the end of each test.

The database for the completed work must be stored and delivered on electronic media. They should include the necessary *software* tools to display, inspect and print any selection of test reports.

A paper copy of the results should be provided, listing all tested *links*, with the following summarized information:

- The identification of the connection in accordance with the naming convention defined in the general system and project documentation.
- The overall pass/fail of the link being tested, including the worst-case attenuation margin (the margin is defined as the difference between the measured value and the test limit value).
- The date and time of the test results that were saved to the test equipment's memory.
- The details of the tests performed on each optical fiber, to be recorded in the database, should have the following information:
  - The identification of the location, as specified by the end user.
  - The approval/rejection of the *link* being tested.
  - The name of the standard selected to run the stored test results.
  - The type of cable and the value of the 'refractive index' used for the length calculations.
  - The date and time that the test results were saved in the test equipment's memory.
  - The brand name, model, and serial number of the test equipment.
  - The review of the test equipment *software* and the review of the database of the test standards used.
- The details of the tests performed on each optical fiber and that will be registered in the database must have the following information:
  - The identification of the link/fiber according to the naming convention defined in the general system/ project documentation.
  - The attenuation measured at each wavelength, the calculated test limit for the corresponding wavelength and margin (difference between the measured attenuation and the test limit value).
  - The length of the link should be reported for each optical fiber where the test limit was calculated.

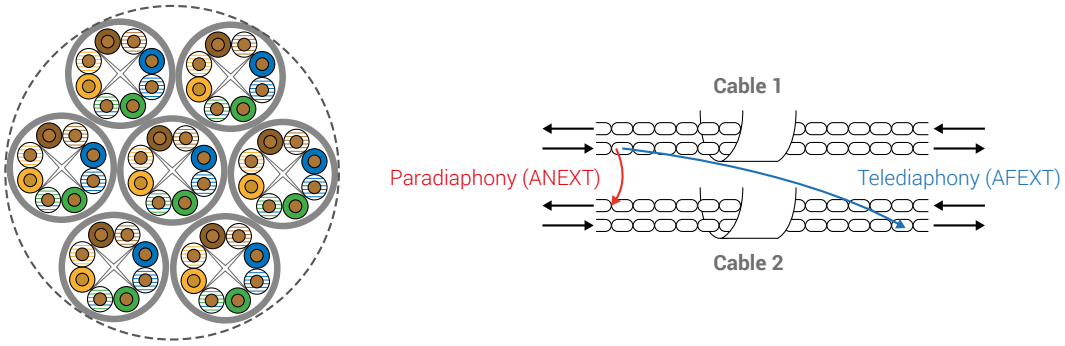
Copper Channel Certification

Before beginning the testing and certification procedure of the structured cabling system on a job site, check:

- Equipment calibrated with the appropriate valid certificate.
- Thermally stabilized equipment (turned on at least 6 minutes before starting the tests).
- Equipment with 100% charged battery.
- Test the certification equipment before starting it.
- Calibrate on-site, when the equipment requires this previous procedure.
- Use appropriate tips or test heads with the application.
- Check the conservation status of the test patch cords for permanent link certification before starting.
- Attention to environmental conditions: 0 °C to +40 °C and humidity 10% to 80%.
- Note that the head must be completely disconnected from network equipment.
- *Links* < 15 m: Current copper structured cabling (metallic) test and certification equipment has been upgraded and short *links* (<15 m) are normally certified, with no distortion in results or 'false' approvals. The *links* are fully measured and the results presented are fully reliable.

Alien Crosstalk:

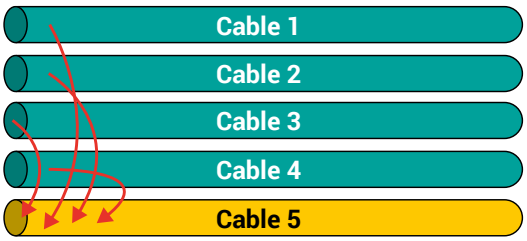
- The UTP cable runs in a structured cabling facility are launched together, grouped into bundles, along an infrastructure or at least part of it. These bundles are organized by velcro or other type of ties. If we apply U/UTP cables, *Alien Crosstalk* appears, interference between signals that propagate through adjacent pairs of cables. The effect of *Alien Crosstalk*, as well as its control, becomes more important in structured cabling systems due to Gigabit Ethernet and 10Gigabit Ethernet. These applications use all pairs of UTP cable, which potentially increases the level of diaphonic interference between pairs of different cables in the system. The applicable standards also define Powersum Alien Crosstalk (*ANEXT* and AFEXT), as well as its limits.



Alien Crosstalk

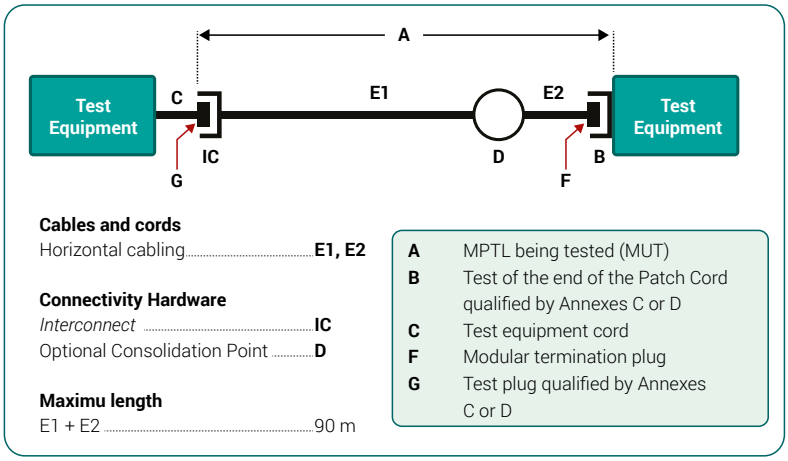
As active data network equipment is generally not able to compensate for external noise coming from cables under certain very specific conditions and limits, it is important that the effects of adjacent cables are minimized in these systems. General rules:

- The effect is primarily due to proximity.
- The crosstalk is worst between pairs of wires with the same twist rate.
- The effect is greater for pairs with a lower twist rate.
- The impact increases with the distance over which the cables run in parallel.
- The impact increases with the frequency of the transmitted signals.



MPTL (MODULAR PLUG TERMINATED LINK)

Allows a solid cable to be connected directly to a plug for direct connection to a device (security camera, *Wi-Fi* point etc.). Transmission requirements: must meet the PL (*Permanent Link*) requirements.



MPTL Channel

For certification testing in this structured cabling configuration, the contents and recommendations of our cabling test equipment partners are highlighted.

From the contents presented, it can be observed that for the certification of this new structured cabling topology, test equipment *software*, tips and test heads must be in place, as recommended by the manufacturers and the new revision of ANSI / TIA-568-2.D.

Extended warranty procedures are up to date and available on the website to update the knowledge bases of FCP projects and training of the Furukawa Institute of Technology (IFT) at Authorized Training Centers (CTAs). As a final recommendation, it is suggested that whenever there is a request to provide extended warranty for cabling in MPTL topology, the Furukawa support area – the implementation –, should be consulted in advance to provide the correct information regarding the standards, test procedures, accepted interfaces and forms of test records

CATEGORY 8

The Category 8 cabling certification tests are described beside by the standards. Also make sure to follow the class of equipment that is to be used in field tests.

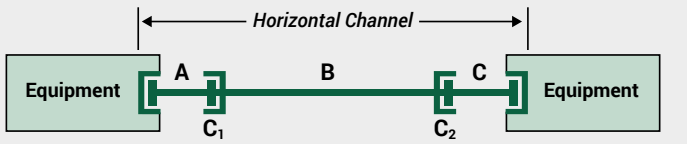
Pay attention to the assembly diagram of the on-site wiring, always observing the following distances. Check the lengths of the components in the field and register them down in *As- built*.

In the case of a direct connection between the devices, observe the maximum recommended length limit for the *patch cord* as shown in the image below.

ISO/IEC 61935-1 Ed.5 (CD)
Specification for the testing of balanced and coaxial information technology cabling – Part 1: Installed balanced cabling as specified in ISO/IEC 11801 and related standards.

ANSI/TIA-1152A
Requeriments for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling.

Class	D	E	E_A	F	F_A	I	II
Level	IIe	III	IIIe	IV	V	VI (Cl.I)	VI (Cl.II)
Cat.	5_E	6	6_A			8	
Level	IIE	III	IIIE			2G	



Cables and cords
Equipment cord ..... **A,C**
Horizontal cabling ..... **B**

Connectivity Hardware
Modular connectivity hardware **C1, C2**

Maximum length
A + C ..... *see table*
B ..... 24 m (79 feet)

Cord~AWG	A + C (m)
22-23	8
24	6
26	4

TEST EQUIPMENT

EXAMPLE - LINKWARE 9.N TM FROM FLUKE

- Manages the test equipment.
- Downloads the equipment tests.
- Exports the tests to PDF format.

SUGGESTIONS:

- Check the user manual of the test equipment manufacturer.
- Follow the calibration and measurement recommendations.
- The use of equipment that has not been calibrated prevents the Extended Warranty from being requested.

Extended Warranty

The quality of components of a communication network infrastructure is a mandatory and not an optional feature.

Along with its installation and distribution channels, Furukawa offers its **Extended Warranty Program**, which ensures the performance of the installed network for up to 25 years.

The Program ensures that the three parties involved in the process deliver a quality network, ensuring the operation of various applications and equipment, with high rate and availability for a long period of time, optimizing the investment.

To request the Extended Warranty, the end client must request it from the *Furukawa Solution Provider* (FSP - Installer) of their choice, who will initiate the process with Furukawa. There is no additional cost for this process, which adds the following advantages to the client:

- Superior performance, ensured by critical analysis of 100% of the certified points.
- Reduced response time to modifications or extensions – the Extended Warranty cabling has better identification of the entire infrastructure, facilitating the location of a network point, link backbone, rack etc.
- Third-party validation – ensures that the installed infrastructure solution meets the requirements of network applications such as 100 Mbps, 1 Gbps, 10 Gbps, 40 Gbps or 100 Gbps.
- Preventive claims risk analysis – verifies the correct use of cables suitable for the application, including the flammability class.
- Increased availability of network services – checks radius of curvature and/or excessive stress in cables and connectors, avoiding disconnections due to fatigue or excessive traction or compression.
- Guaranteed technical records and As-Built projects, which facilitate future expansions.
- A more reliable and guaranteed network for up to 25 years.

The warranty is effective from the issuance of the Extended Warranty Certificate, which is granted upon approval of the submitted documentation and inspection of the work carried out by Furukawa or an authorized company. It must be requested up to six months after the construction of the network.

After completion of the process, the records generated are archived and available to the client and integrator (*Furukawa Solution Provider*).

Further information can be obtained from the Furukawa channels.

Training Professionals for Data Centers

My challenge is market specialization. Professionals increasingly aware of their areas of expertise through practical courses, reducing errors and increasing productivity. More qualified professionals, in less time.

IFT Coach (Furukawa Institute of Tecnology)

Furukawa Institute of Technology

TRAINING AND CONTINUING EDUCATION PROGRAM

Furukawa has been gradually innovating the training model aiming at professional specialization, developing training with the support of universities, instructors and technological partners, in order to optimize time in class and increase knowledge of professional market.

The market demands specialized professionals. Practical courses are a solution for speeding up learning, reducing errors and increasing productivity due to technical qualification. This provides companies with the possibility of having more qualified professionals in their staff, in less time.

To meet this scenario, the Furukawa Institute of Technology was created, a Continuing Education System, which has already trained more than 70,000 professionals through distance learning and on-site courses held by Furukawa, Authorized Training Centers and Universities.

Designed to support and qualify professionals in the understanding, installation and best practices of use of connectivity solutions, has more than 236 hours of classroom courses. The whole program has international recognition from BICSI (Building Industry Consulting Service International), an internationally recognized professional association that supports the advancement of communication and information technology by attesting to quality of our training.

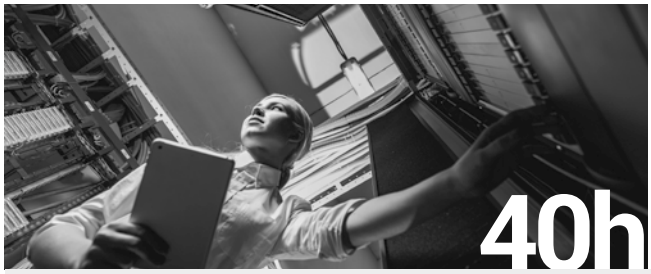
2017	2018	2019
6,773 students	**9,770 students**	**8,909 students**

Courses focused on Data Centers

In the Data Center course, four training modules are offered to train the professional:

Data Cabling System

Concepts and installation of structured cabling networks.

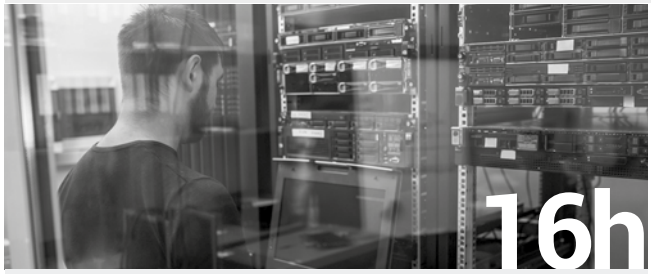


FCP Master

Trains the professional in the elaboration and distribution of cabling networks and Data Center through the analysis of a real situation.

Data Center Module

Trains the professional to understand, specify and design the infrastructure of a Data Center, based on Furukawa Solutions.



Management Module

Trains the professional to manage the physical layer of the network through the DataWave Solution.

The Data Cabling System and FCP Master modules are available in the Furukawa Authorized Training Centers network and the Data Center and DataWave modules are delivered to Furukawa clients, integrators and distributors.

Training in Good Installation Practices

On-site - delivered by the engineering team

at Furukawa to authorized integrators and distributors,

suited to the needs of the channel. Modules:

1. *Introduction*: basic wiring concepts and their characteristics.
2. *Structured Cabling*: virtual visit to a company to learn about cabling and its topologies.
3. *Installation*: study of the main problems encountered in day-to-day life and procedures for a good installation.
4. *Conclusion*: installation simulation, with the objective of studying what was learned during the course (only in *e-learning).*

PRODUCT REFERENCE

COPPER SOLUTION

SHIELDED KEYSTONE JACK GIGALAN AUGMENTED CAT.6A T568A/B

DATA CABLE GIGALAN GREEN U/UTP 23AWGX4P CAT.6 LSZH IEC 60332-3 VD RIB

DATA CABLE GIGALAN GREEN U/UTP 23AWGX4P CAT.6 LSZH IEC 60332-3 CZ RIB

DATA CABLE GIGALAN GREEN U/UTP 23AWGX4P CAT.6 LSZH IEC 60332-3 AZ RIB

F/UTP CAT.6A COPPER PATCH CORD GIGALAN AUGMENTED GREEN - LSZH - T568A/B - 1.5M - BLUE (SHIELDED)

F/UTP CAT.6A COPPER PATCH CORD GIGALAN AUGMENTED GREEN - LSZH - T568A/B - 1.5M - GRAY (SHIELDED)

F/UTP CAT.6A COPPER PATCH CORD GIGALAN AUGMENTED GREEN - LSZH - T568A/B - 1.5M - GREEN (SHIELDED)

F/UTP CAT.6A COPPER PATCH CORD GIGALAN AUGMENTED GREEN - LSZH - T568A/B - 2.5M - BLUE (SHIELDED)

F/UTP CAT.6A COPPER PATCH CORD GIGALAN AUGMENTED GREEN - LSZH - T568A/B - 2.5M - GRAY (SHIELDED)

F/UTP CAT.6A COPPER PATCH CORD GIGALAN AUGMENTED GREEN - LSZH - T568A/B - 3.0M - BLUE (SHIELDED)

F/UTP CAT.6A COPPER PATCH CORD GIGALAN AUGMENTED GREEN - LSZH - T568A/B - 3.0M - GRAY (SHIELDED)

F/UTP CAT.6A COPPER PATCH CORD GIGALAN AUGMENTED GREEN - LSZH - T568A/B - 3.0M - GREEN (SHIELDED)

F/UTP CAT.6A COPPER PATCH CORD GIGALAN AUGMENTED GREEN - LSZH - T568A/B - 5.0M - BLUE (SHIELDED)

F/UTP CAT.6A COPPER PATCH CORD GIGALAN AUGMENTED GREEN - LSZH - T568A/B - 5.0M - GRAY (SHIELDED)

F/UTP CAT.6A COPPER PATCH CORD GIGALAN AUGMENTED GREEN - LSZH - T568A/B - 5.0M - GREEN (SHIELDED)

F/UTP CAT.6A RJ-45 SOLID EXTENSION GIGALAN AUGMENTED GREEN - LSZH - T568A - 2.5M - GRAY (SHIELDED)

F/UTP CAT.6A RJ-45 SOLID EXTENSION GIGALAN AUGMENTED GREEN - LSZH - T568A - 2.5M - GREEN (SHIELDED)

F/UTP CAT.6A RJ-45 SOLID EXTENSION GIGALAN AUGMENTED GREEN - LSZH - T568A - 5.0M - GRAY (SHIELDED)

F/UTP CAT.6A RJ-45 SOLID EXTENSION GIGALAN AUGMENTED GREEN - LSZH - T568A - 5.0M - GREEN (SHIELDED)

F/UTP CAT.6A RJ-45 SOLID EXTENSION GIGALAN AUGMENTED GREEN - LSZH - T568B - 2.5M - GRAY (SHIELDED)

F/UTP CAT.6A RJ-45 SOLID EXTENSION GIGALAN AUGMENTED GREEN - LSZH - T568B - 2.5M - GREEN (SHIELDED)

F/UTP CAT.6A RJ-45 SOLID EXTENSION GIGALAN AUGMENTED GREEN - LSZH - T568B - 5.0M - GRAY (SHIELDED)

F/UTP CAT.6A RJ-45 SOLID EXTENSION GIGALAN AUGMENTED GREEN - LSZH - T568B - 5.0M - GREEN (SHIELDED)

OPTICAL SOLUTION

ODF MODULAR HDX 1U - BASIC MODULE

HDX MODULAR PATCH PANEL

HDX CONNECTION BOX - 3 SLOTS

ODF CASSETTE PREMIUM HDX 12F OM5 LC-UPC/MPO12-UPC(F) TYPE B REVERSE

ODF CASSETTE PREMIUM HDX 12F OM5 LC-UPC/MPO12-UPC(F) TYPE B STRAIGHT

ODF CASSETTE PREMIUM HDX 12F OM4 LC-UPC/MPO12-UPC(F) TYPE B REVERSE

ODF CASSETTE PREMIUM HDX 12F OM4 LC-UPC/MPO12-UPC(F) TYPE B STRAIGHT

ODF CASSETTE PREMIUM HDX 12F BLI A/B G-657A LC-UPC/MPO12-UPC(F) TYPE B REVERSE

ODF CASSETTE PREMIUM HDX 12F BLI A/B G-657A LC-UPC/MPO12-UPC(F) TYPE B STRAIGHT

OPTICAL CABLE FIBER-LAN INDOOR 12F MM (50) OM5 LSZH (LIME GREEN)

OPTICAL CABLE CFOT-MM-EO 12F (50) OM4 LSZH (FIBER-LAN INDOOR/OUTDOOR)

OPTICAL CABLE CFOT-SM-EO 12F LSZH (FIBER-LAN INDOOR/OUTDOOR)

TRUNK CABLE PRE-TERMINATED PREMIUM 12F OM5 MPO12-UPC(U)/MPO12-UPC(U) 0.8D3/0.8D3 - 10.0M - UT - LSZH - LIME GREEN - TYPE U

TRUNK CABLE PRE-TERMINATED PREMIUM 12F OM5 MPO12-UPC(U)/MPO12-UPC(U) 0.8D3/0.8D3 - 25.0M - UT - LSZH - LIME GREEN - TYPE U

OPTICAL PATCH CORD PREMIUM 12F OM5 MPO12-UPC(U)/MPO12-UPC(U) 3.0D3 - MTF - LSZH - LIME GREEN

DUPLEX OPTICAL PATCH CORD PREMIUM OM5 LC(UB)-UPC/LC(UB)-UPC - 3.0M - LSZH - LIME GREEN (A - B)

TRUNK CABLE PRE-TERMINATED 12F OM4 MPO12-UPC(M)/MPO12-UPC(M) 0.8D3/0.8D3 10.0M - UT - LSZH - AQUA - TYPE B

TRUNK CABLE PRE-TERMINATED 12F OM4 MPO12-UPC(M)/MPO12-UPC(M) 0.8D3/0.8D3 30.0M - UT - LSZH - AQUA - TYPE B

TRUNK CABLE PRE-TERMINATED 12F OM4 MPO12-UPC(M)/MPO12-UPC(M) 0.8D3/0.8D3 50.0M - UT - LSZH - AQUA - TYPE B

TRUNK CABLE PRE-TERMINATED 12F OM4 MPO12-UPC(M)/MPO12-UPC(M) 0.8D3/0.8D3 100.0M - UT - LSZH - AQUA - TYPE B

TRUNK CABLE PRE-TERMINATED PREMIUM 12F OM4 MPO12-UPC(U)/MPO12-UPC(U) 0.8D3/0.8D3 10.0M - UT - LSZH - ACQUA

TRUNK CABLE PRE-TERMINATED PREMIUM 12F OM4 MPO12-UPC(U)/MPO12-UPC(U) 0.8D3/0.8D3 30.0M - UT - LSZH - ACQUA

TRUNK CABLE PRE-TERMINATED PREMIUM 12F OM4 MPO12-UPC(U)/MPO12-UPC(U) 0.8D3/0.8D3 50.0M - UT - LSZH - ACQUA

TRUNK CABLE PRE-TERMINATED PREMIUM 12F OM4 MPO12-UPC(U)/MPO12-UPC(U) 0.8D3/0.8D3 100.0M - UT - LSZH - ACQUA

TRUNK CABLE PRE-TERMINATED FANOUT PREMIUM 12F OM4 LC(UB)-UPC/MPO12-UPC(U) 1.0D2/0.8D3 10.0M - UT - LSZH - ACQUA

TRUNK CABLE PRE-TERMINATED FANOUT PREMIUM 12F OM4 LC(UB)-UPC/MPO12-UPC(U) 1.0D2/0.8D3 20.0M - UT - LSZH - ACQUA

OPTICAL PATCH CORD 12F PREMIUM OM4 MPO12-UPC(U)/MPO12-UPC(U) 5.0D3 - MTF - LSZH - ACQUA

OPTICAL PATCH CORD 12F PREMIUM OM4 MPO12-UPC(U)/MPO12-UPC(U) 10.0D3 - MTF - LSZH - ACQUA

OPTICAL PATCH CORD 12F PREMIUM OM4 MPO12-UPC(U)/MPO12-UPC(U) 20.0D3 - MTF - LSZH - ACQUA

OPTICAL PATCH CORD FANOUT 12F PREMIUM OM4 LC(UB)-UPC/MPO12-UPC(U) 0.7D2/5.0D3 - MTF - LSZH - ACQUA

OPTICAL PATCH CORD FANOUT 12F PREMIUM OM4 LC(UB)-UPC/MPO12-UPC(U) 0.7D2/10.0D3 - MTF - LSZH - ACQUA

OPTICAL PATCH CORD FANOUT 12F PREMIUM OM4 LC(UB)-UPC/MPO12-UPC(U) 0.7D2/20.0D3 - MTF - LSZH - ACQUA

DUPLEX OPTICAL PATCH CORD PREMIUM OM4 LC(UB)-UPC/LC(UB)-UPC - 2.5M - LSZH - AQUA (A - B)

DUPLEX OPTICAL PATCH CORD PREMIUM OM4 LC(UB)-UPC/LC(UB)-UPC - 5.0M - LSZH - AQUA (A - B)

OPTICAL PATCH CORD FANOUT 08F-40G OM4 LC-UPC/MPO12-UPC(F) 0.7D2/1.0D3 - MTF - LSZH - ACQUA

OPTICAL PATCH CORD FANOUT 08F-40G OM4 LC-UPC/MPO12-UPC(F) 0.7D2/2.0D3 - MTF - LSZH - ACQUA

OPTICAL PATCH CORD FANOUT 08F-40G OM4 LC-UPC/MPO12-UPC(F) 0.7D2/5.0D3 - MTF - LSZH - ACQUA

TRUNK CABLE PRE-TERMINATED 12F SM BLI A/B G-657A MPO12-APC(M)/MPO12-APC(M) 0.8D3/0.8D3 10.0M - UT - LSZH - YELLOW - TYPE B

TRUNK CABLE PRE-TERMINATED 12F SM BLI A/B G-657A MPO12-APC(M)/MPO12-APC(M) 0.8D3/0.8D3 30.0M - UT - LSZH - YELLOW - TYPE B

TRUNK CABLE PRE-TERMINATED 12F SM BLI A/B G-657A MPO12-APC(M)/MPO12-APC(M) 0.8D3/0.8D3 50.0M - UT - LSZH - YELLOW - TYPE B

TRUNK CABLE PRE-TERMINATED 12F SM BLI A/B G-657A MPO12-APC(M)/MPO12-APC(M) 0.8D3/0.8D3 100.0M - UT - LSZH - YELLOW - TYPE B

TRUNK CABLE PRE-TERMINATED PREMIUM 12F SM BLI-A/B G-657A MPO12-APC(U)/MPO12-APC(U) 0.8D3/0.8D3 30.0M - UT - LSZH - YELLOW

TRUNK CABLE PRE-TERMINATED PREMIUM 12F SM BLI-A/B G-657A MPO12-APC(U)/MPO12-APC(U) 0.8D3/0.8D3 50.0M - UT - LSZH - YELLOW

TRUNK CABLE PRE-TERMINATED PREMIUM 12F SM BLI-A/B G-657A MPO12-APC(U)/MPO12-APC(U) 0.8D3/0.8D3 100.0M - UT - LSZH - YELLOW

TRUNK CABLE PRE-TERMINATED FANOUT PREMIUM 12F SM BLI A/B G-657A LC(UB)-UPC/MPO12-APC(U) 1.0D2/0.8D3 10.0M - UT - LSZH - YELLOW

TRUNK CABLE PRE-TERMINATED FANOUT PREMIUM 12F SM BLI A/B G-657A LC(UB)-UPC/MPO12-APC(U) 1.0D2/0.8D3 20.0M - UT - LSZH - YELLOW

OPTICAL PATCH CORD FANOUT PREMIUM 12F SM BLI A/B G-657A LC(UB)-UPC/MPO12-APC(U) 0.7D2/5.0D3 - MTF - LSZH - YELLOW

OPTICAL PATCH CORD FANOUT PREMIUM 12F SM BLI A/B G-657A LC(UB)-UPC/MPO12-APC(U) 0.7D2/10.0D3 - MTF - LSZH - YELLOW

OPTICAL PATCH CORD FANOUT PREMIUM 12F SM BLI A/B G-657A LC(UB)-UPC/MPO12-APC(U) 0.7D2/20.0D3 - MTF - LSZH - YELLOW

OPTICAL PATCH CORD PREMIUM 12F SM BLI A/B G-657A MPO12-APC(U)/MPO12-APC(U) 5.0D3 - MTF - LSZH - YELLOW

OPTICAL PATCH CORD PREMIUM 12F SM BLI A/B G-657A MPO12-APC(U)/MPO12-APC(U) 10.0D3 - MTF - LSZH - YELLOW

OPTICAL PATCH CORD PREMIUM 12F SM BLI A/B G-657A MPO12-APC(U)/MPO12-APC(U) 20.0D3 - MTF - LSZH - YELLOW

DUPLEX OPTICAL PATCH CORD PREMIUM SM BLI A/B G-657A LC(UB)-UPC/LC(UB)-UPC - 2.5M - LSZH - YELLOW (A - B)

DUPLEX OPTICAL PATCH CORD PREMIUM SM BLI A/B G-657A LC(UB)-UPC/LC(UB)-UPC - 5.0M - LSZH - YELLOW (A - B)

DUPLEX OPTICAL PATCH CORD PREMIUM SM BLI A/B G-657A LC(UB)-UPC/LC(UB)-UPC - 10.0M - LSZH - YELLOW (A - B)

TOOL KIT FOR UNIVERSAL MPO

CLEANING TOOL - LC

CLEANING TOOL - MPO

INFRASTRUCTURE ACCESSORIES

BRACKET 19"x 6U (KIT 2 UNITS)

UNLOADED SHIELDED CONNECTION BOX - 12 SLOTS

HIGH DENSITY CONNECTION BOX 6U

LGX CONNECTION BOX - 2 SLOTS

LGX CONNECTION BOX - 4 SLOTS

UTP SHIELDED PATCH PANEL 24P

UTP SHIELDED ANGLED PATCH PANEL 24P 1/2U (UNLOADED)

UTP SHIELDED PATCH PANEL 24P 1/2U (UNLOADED)

OPEN HORIZONTAL CABLE MANAGER 1/2U

BLANK PANEL 1/2U

ANGLED TOP COVER 1/2U - (USED WITH ANGLED PATCH PANEL 1/2U)

OPEN RACK 2P 19" 45U ITMAX

OPEN RACK 4P 19" 45U ITMAX

ITMAX VERTICAL CABLE MANAGER 200MM - SINGLE DOOR

ITMAX VERTICAL CABLE MANAGER BETWEEN RACKS 315MM - SINGLE DOOR

ITMAX UP AND BOTTOM RACK TRAY

ITMAX HORIZONTAL CABLE MANAGER 2U

ITMAX HORIZONTAL CABLE MANAGER 4U

ITMAX HORIZONTAL CABLE MANAGER 2U - DOUBLE SIDE

ITMAX PLASTIC SPOOL (5 PIECES)

ITMAX SIDE COVER FOR VERTICAL MANAGER - SINGLE DOOR

ITMAX GROUNDING BAR

SERVER CABINET 42U X 600MM X 1100MM

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