ITMAX

APPLICATION GUIDE
TeraPatch™ Platform

High-Density Infrastructure
Solutions for DCs

Lightera

Index

1 Introduction

Purpose of the Guide

The purpose of this guide is to provide a clear, practical, and reliable reference for the application of the TeraPatch™ Platform in data center environments, ensuring alignment between scalability, performance, security, availability, and operational efficiency. This guide was developed to support engineering, operation, planning, commercial and decision-making teams, presenting guidance on application, integration, installation and specification of products, as well as good practices related to the infrastructure of mission-critical environments.

In addition to standardizing processes and reducing technical ambiguities, the guide seeks to facilitate communication between Lightera, designers, integrators and end customers, promoting consistent and sustainable solutions. By establishing objective criteria and recommendations for use, the guide contributes to minimizing risks, optimizing investments, ensuring regulatory compliance and accelerating the adoption of emerging technologies, always focusing on the reliability and continuity of essential services.

The guide has an Annexes section that constitutes a complementary collection of information, technical references and support resources developed specifically to subsidize and enhance complements to projects that implement Lightera's TeraPatch™ Platform.

Technology trends

As it is a market in growing expansion in the world and, mainly driven by the explosive demand for digital services, cloud computing, and Artificial Intelligence (AI), the technological dynamism of the sector is an important item to be taken into account when you want to understand the next steps. Because of this, some technological trends are seen as indispensable in a short-term scenario. Among them, the following can be highlighted:

HPC Acceleration and the Thermodynamic Revolution: The demand for generative AI raises the installed load density in a rack from approximately 5 kW to 40 kW, 100 kW, 150 kW or more, making Direct-to-Chip (D2C) liquid cooling and new electrical distribution architectures at 800 VDC for loads that can reach up to 1 MW.

Hyperscale Market Consolidation and the Capacity Crunch: Cloud providers are pre-leasing large data center campuses, creating a structural supply shortage that can drive up prices in the "wholesale" colocation market.

Distributed Architectures as a Latency Reduction and Regulatory Solution: The convergence of 5G, IoT, and Edge Computing decentralizes processing to meet ultra-low latency applications and data localization requirements.

ESG and Resource Governance: The data center becomes the focal point in the energy transition, requiring the adoption of comprehensive metrics (PUE, CUE, WUE) and the integration of microgrids and renewable energy sources.

Automation and the Rise of the Data Center Autonomous: The AI-driven evolution of DCIM (DCIM 2.0) enables predictive fault management and dynamic optimization of energy consumption, mitigating increasing operational complexity and talent shortages.

2 The TeraPatch™ Platform

What is the TeraPatch™ Platform?

The TeraPatch™ Platform is a high-performance optical infrastructure developed by Lightera to meet contemporary demands for connectivity, density and scalability in data center environments and telecommunications networks.

Based on standardized modular technology, the TeraPatch™ Platform was designed to provide an efficient and economically viable response to the challenges posed by digital transformation, the exponential growth in demand for bandwidth and the accelerated evolution of technologies such as Artificial Intelligence, cloud computing and high-performance processing.

Three Strategic Pillars

The TeraPatch™ Platform rests on three fundamental pillars that define its market positioning:

Space Reduction

By supporting a greater number of optical connections in a reduced physical space, the TeraPatch™ Platform expands the capacity for service and revenue generation without the need for significant infrastructure expansions, also contributing to environmental sustainability.

High Density

Intelligent concentration of connections in environments with high transmission rates (400G, 800G, 1.6T) simplifies cable management and facilitates maintenance, maximizing the utilization of available space and reducing capital investments (CapEx) and operating costs (OpEx).

Scalability

Thanks to its standardized modular architecture, the TeraPatch™ Platform allows for rapid and non-disruptive expansions, in line with the pace of business growth. New capabilities are deployed in hours, not weeks, preserving previous investments and turning infrastructure into a competitive growth engine.

Why TeraPatch™ Platform?

In a context where speed of innovation, operational efficiency, and profitability define market leaders, the TeraPatch™ Platform offers a proven alternative: an infrastructure that grows with your business, without technical bottlenecks, without operational interruptions, and without budget surprises.

Whether for expanding data centers, cloud service providers, telecom operators, or enterprises looking to consolidate their digital presence, the TeraPatch™ Platform translates technical complexity into operational simplicity and investments into competitive advantage.

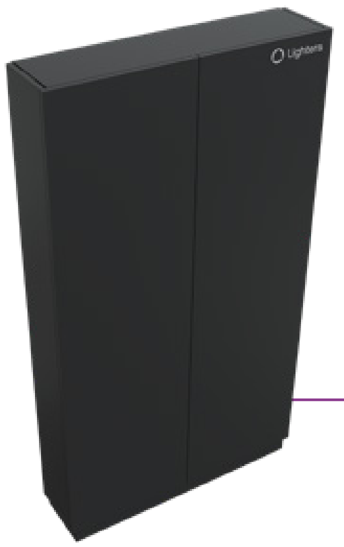
This guide will walk you through every step of the implementation, from planning to operation, ensuring that you fully take advantage of the transformative potential of the TeraPatch™ Platform.

TeraPatch™ Platform Components

TERAPATCH™ CABINET 45U HIGH DENSITY

The **TERAPATCH™ CABINET 45U - HIGH DENSITY** Cabinet is designed and optimized for high-density deployment and storage of optical terminations and connections in *enterprise, collocation, cloud*, AI, and/or HPC data centers. It presents the requirements for the proper performance of massive or single fusions, as well as LC pre-connectorized terminations.

The TERAPATCH™ CABINET 45U - HIGH DENSITY features a multifunctional structure for high density, optimized to house modules for the termination and distribution of fiber optic cables with high fiber formation of the Rollable Ribbon type or simple formation with multitube cables.



It is a high-density, shallow-depth solution for data center and telecommunications environments with the possibility of various configurations of mounting layouts.

Provides front access for installation, and side and back access for operation and maintenance, allowing removal of all protective plates and doors.

Wide entry/exit paths for cables and optical cords on the top (with brushes), sides and bottom (removal of plates) of the TERAPATCH™ CABINET 45U - HIGH DENSITY.

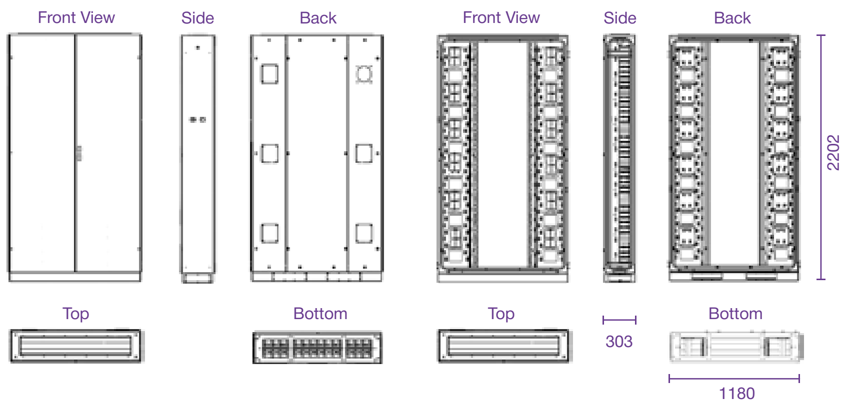
Solid and smooth, double front, removable and 2-point locking doors with cremone type lock.

Standalone structure suitable for distribution of up to 3,456 fibers with LC connectors for *ribbon* and massive fusion optical cables.

NOTE: Using tight multitube cables and single fusion, this capacity is reduced to up to 1728 fibers.

Orthogonal Projections

In order to assist in the dimensional vision of the TeraPatch™ Cabinet 45U – High Density, the following are the orthogonal projections with the measurements, in millimeters:



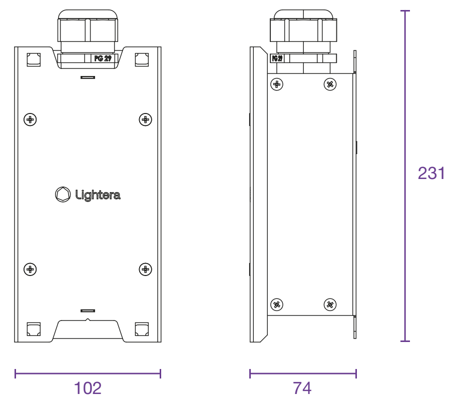
Lightera Part Number	Description	Technical Specification
35150634	TeraPatch™ Cabinet 45U - High Density	ET07356

TeraPatch™ TRANSITION BOX

The TeraPatch™ Transition Box module is a rugged and compact solution designed to manage the transition and distribution of high-formation optical cables in data centers.
Ideal for applications requiring superior protection, efficient organization, and easy accessibility for optical cables with up to 1728 fibers, making it easy to connect to the ODF TeraPatch™ Fusion Module 4U.

Orthogonal Projections

In order to assist in the dimensional view of the TeraPatch™ Transition Box Module, the orthogonal projections with the measurements in millimeters are as follows:



Lightera Part Number	Description	Technical Specification
35150640	TeraPatch™ Transition Box Module 1728F/864F - 12 X 144F/72F	ET07452

ODF TERAPATCH™ FUSION MODULE 4U

Module responsible for protecting massive and simple fusions, consisting of two main components, assembled in the factory:

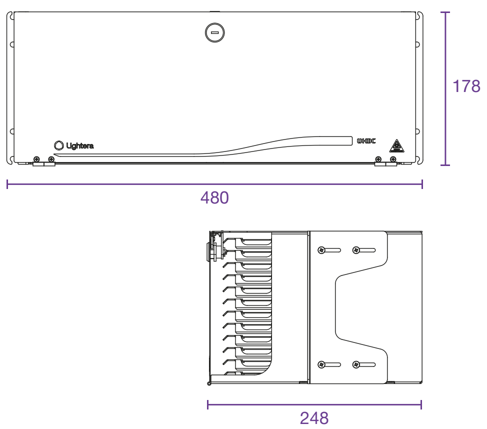
ODF TeraPatch™ FUSION MODULE 4U – Basic module – module responsible for accommodating and protecting the trays of optical splices of transition between the optical input cable and the optical extensions (pigtails) of the ODF TeraPatch™ Termination Module 3U 288F. Supplied with 12 trays with splice protectors.

Splice Tray Kit – Set of accessories to accommodate optical fusions within the ODF module, composed of 12 splice trays for massive and simple fusions. Each tray of the base module must be assembled with a tray kit in order for the ODF to meet its maximum fusion capacity.

Capacity for 1728 massive fusions in groups of 12 or 864 single fusions in groups of 12.

Orthogonal Projections

In order to assist in the dimensional view of the ODF TeraPatch™ Fusion Module 4U, the following are the orthogonal projections with the measurements, in millimeters:



Lightera Part Number	Description	Technical Specification
35261310	ODF TeraPatch™ Massive Fusion Module 4U 1728F - 12 X 144F	ET07360

ODF TeraPatch™ TERMINATION MODULE

Module responsible for the mirroring of optical fibers, consisting of the following main components:

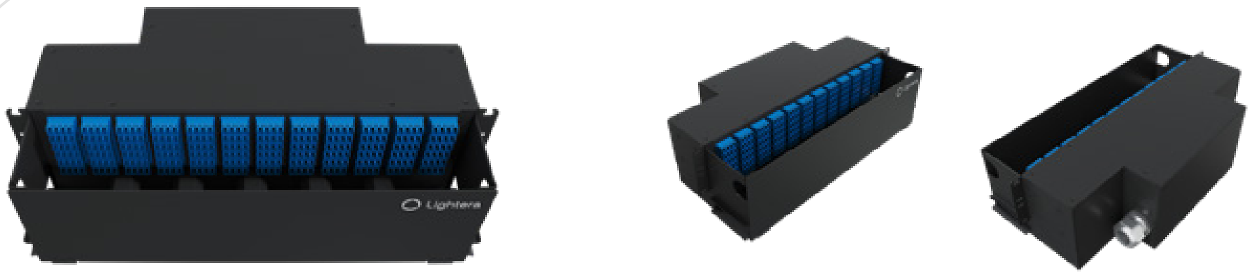
ODF TeraPatch™ Termination Module 3U 288F – Basic Module: Responsible for accommodating and protecting optical extensions (ribbon pigtails or simple pigtails).

Connectorized Optical Extensions: Each optical extension, in ribbon or single versions, has 12 fibers with a connectorized end with LC connector. Ideal for applications with massive or single fusion of fibers next to the TeraPatch™ ODF FUSION 4U module.

Optical adapters: Capacity for 288 fibers with LC type connectors (with shutter).

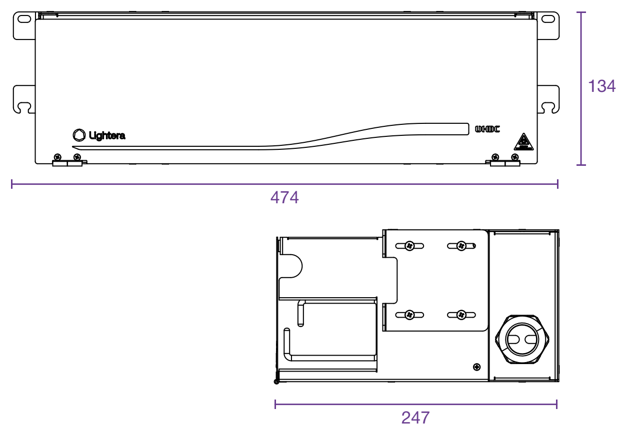
APC Polish:

UPC Polish:



Orthogonal Projections

In order to assist in the dimensional view of the ODF TERAPATCH™ TERMINATION MODULE 3U 288F, the orthogonal projections with the measurements in millimeters are as follows:



Lightera Part Number	Description	Technical Specification
35261311	ODF TeraPatch™ Termination Module 3U 288F LC-APC - 2 X 144F	ET07359

TeraPatch™ Platform Components

Summary table of components

Lightera Part Number	Description	Technical Specification
35150634	TeraPatch™ Cabinet 45U - High Density	ET07356
35150640 35150642	TeraPatch™ Transition Box Module 1728F/864F - 12 X 144F/72F TeraPatch™ Transition Box Module 288F - 8 X 36F	ET07452
35261310 35261329	ODF TeraPatch™ Massive Fusion Module 4U 1728F - 12 X 144F ODF TeraPatch™ Simple Fusion Module 4U 864F - 12 X 72F	ET07360
35261311 35261330 35261333 35261334	ODF TeraPatch™ Termination Module 3U 288F LC-APC - 2 X 144F ODF TeraPatch™ Termination Module 3U 288F LC-APC - 4 X 72F ODF TeraPatch™ Termination Module 3U 288F LC-UPC - 2 X 144F ODF TeraPatch™ Termination Module 3U 288F LC-UPC - 4 X 72F	ET07359

Fusion

In data centers that adopt high-density optical architectures, the choice between single fusions and massive fusions plays a strategic role in the organization, reliability, and efficiency of the cabling system. Compact ODFs, increasingly employed in critical environments, require termination methods that reduce internal volume, minimize optical loss, and accelerate deployment time. In this context, the TeraPatch™ Platform fits ideally into the requirements needed for strategic business growth.

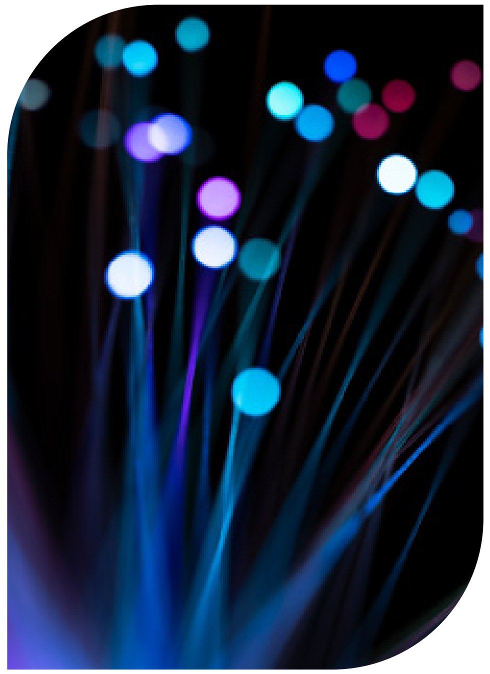
The TeraPatch™ ODF Fusion 4U Module is designed to make the accommodation and protection of transition optical splices hassle-free. Its high density, aligned with scalability and space reduction make the type of fusion (single or massive) a design parameter that does not impact other applications.

Lightera recommends the use of massive fusion and ribbon cables to take full advantage of the TeraPatch™ Platform.

Massive Fusion

Massive fusions, in turn, are applied when there is a need to interconnect large amounts of fibers simultaneously. Using alignment devices and pre-arranged components, massive fusions of 12 fibers at a time optimize deployment time, reduce the volume of cables within the ODF and ensure a more efficient occupation of physical space. In the TeraPatch™ Platform, there is also the possibility of performing massive fusion on the ribbons so that the accommodation and protection of the optical splices is not an obstacle, but rather a competitive advantage.

To carry out massive fusion, Lightera has equipment developed specifically for this purpose. One of them is the S124X fusion machine, in which it is possible to splice individual fibers and ribbons of up to 12 fibers. The splicing machine can be used to splice 200µm fiber rollable tapes by changing only the V-groove.



It has the following characteristics:

- ✓ Splicing of tapes of up to 12 fibers;
- ✓ High splicing speed of 15 seconds;
- ✓ Interchangeable V-slot system;
- ✓ 200 µm coating fiber tape is applicable by changing the V-groove;
- ✓ Easy operation with touch panel and GUI3 LED lights allow convenient loading of fibers into the V-slot;
- ✓ Wi-Fi connection allows wireless control and data management.

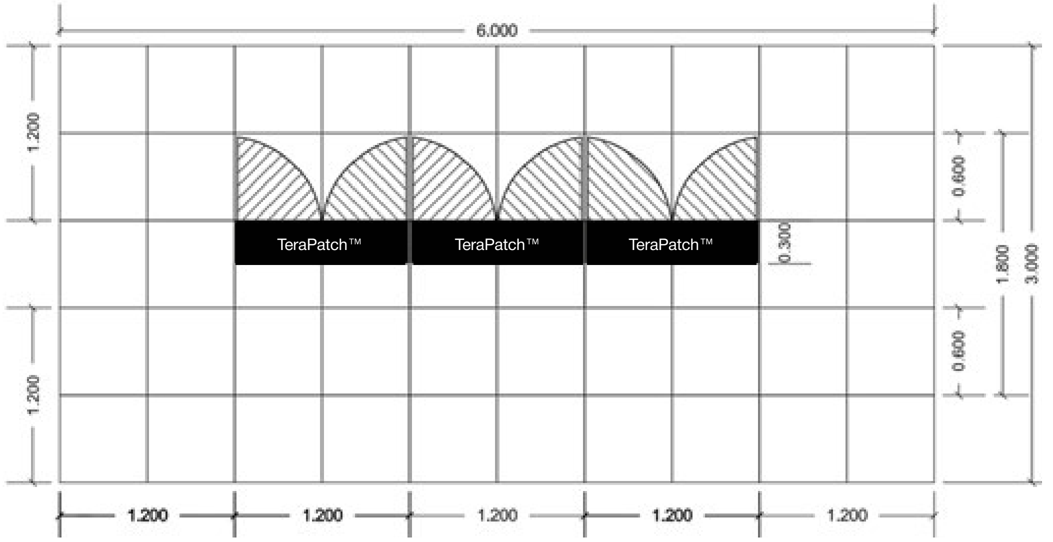
Simple Fusion

Simple fusions are widely used in applications that require greater individual control over each fiber. This method uses the fusion of one fiber at a time, offering excellent optical performance, very low typical loss and high repeatability. In the TeraPatch™ Platform, simple fusions are applied in optimized trays, allowing the organized accommodation of splice protectors and facilitating maintenance or specific relocations per fiber.

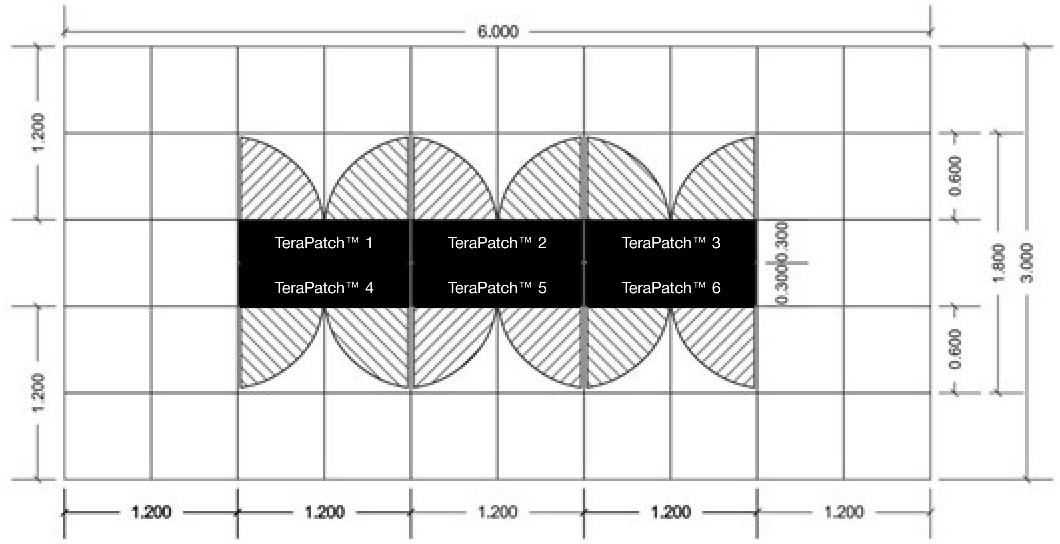
Assembly Layouts for the TeraPatch™ Platform

When it comes to having a spatial notion of the project and ways to implement the solution, it is essential to visualize different ways of accommodation. Because of this, there are mounting layouts with suggested spacing, such as: **Side-by-side, Rear with Rear and Against wall**. In the following topics, some types are presented, with distances in meters.

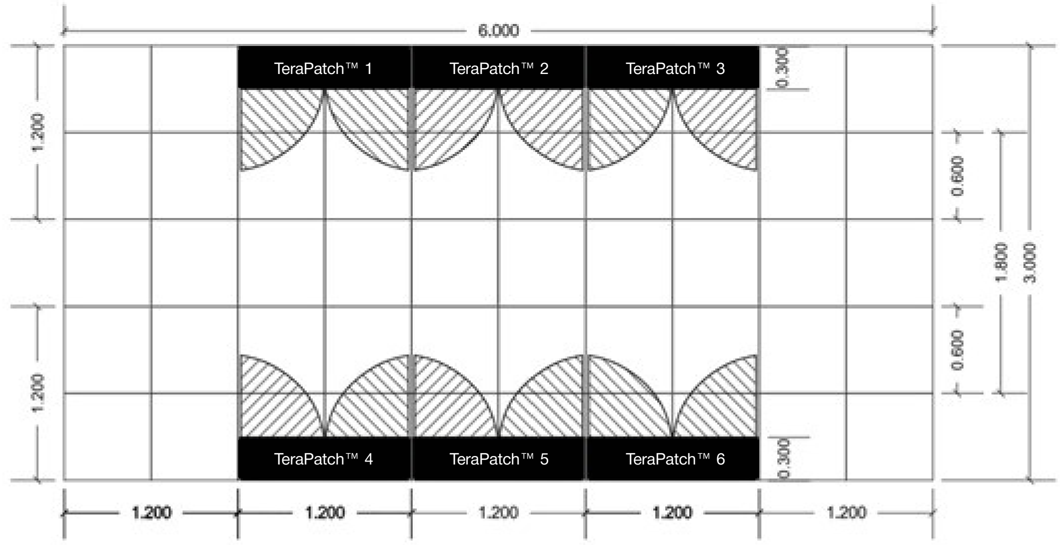
Side-by-side Mounting



Rear-to-Rear Mounting



Against Wall Mounting



Note: Suggested distances and spaces.

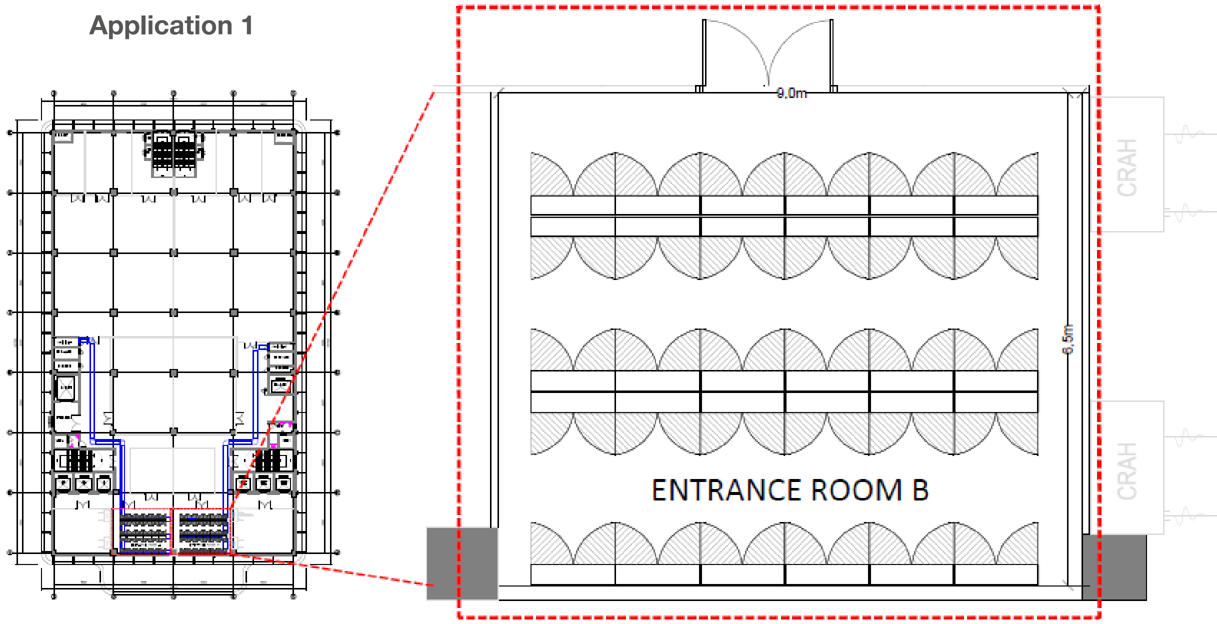
TeraPatch™ Platform Applications

The examples presented here are suggested implementations, and there may be derivative and alternative versions of those presented here.

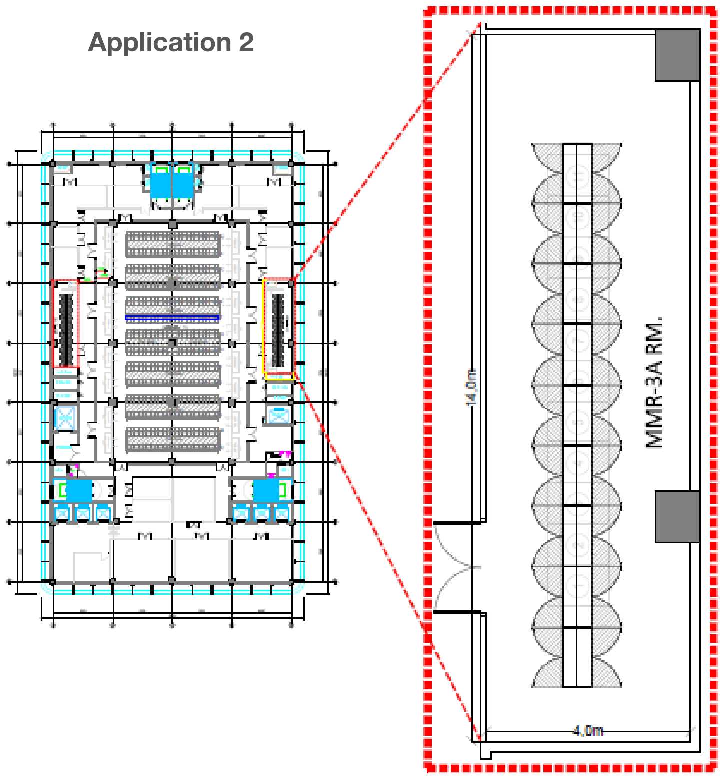
Colocation DC

It is possible to carry out applications in various types of data centers, including Colocation. The following are some illustrations of the TeraPatch™ Platform in this scenario.

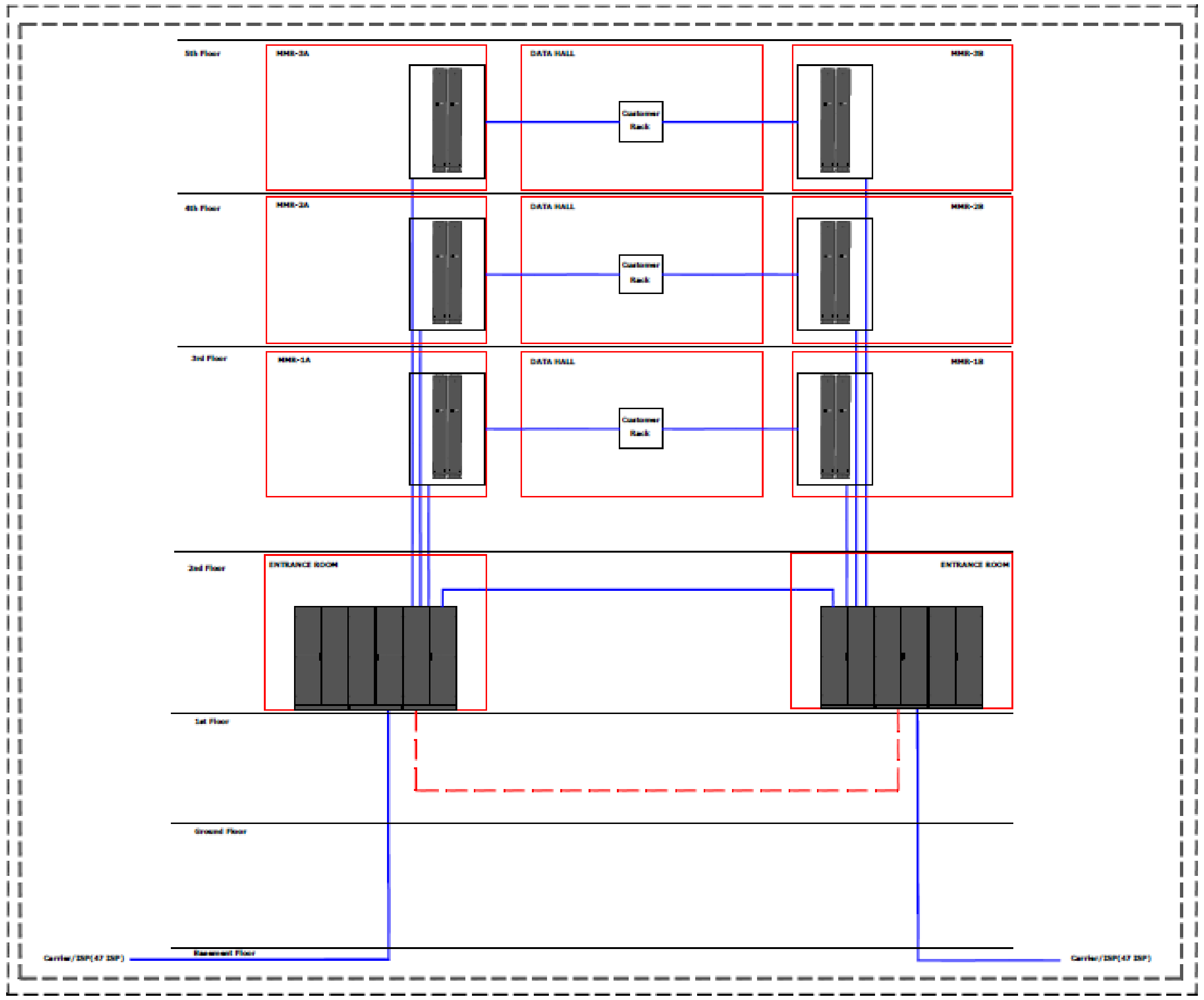
Application 1



Application 2

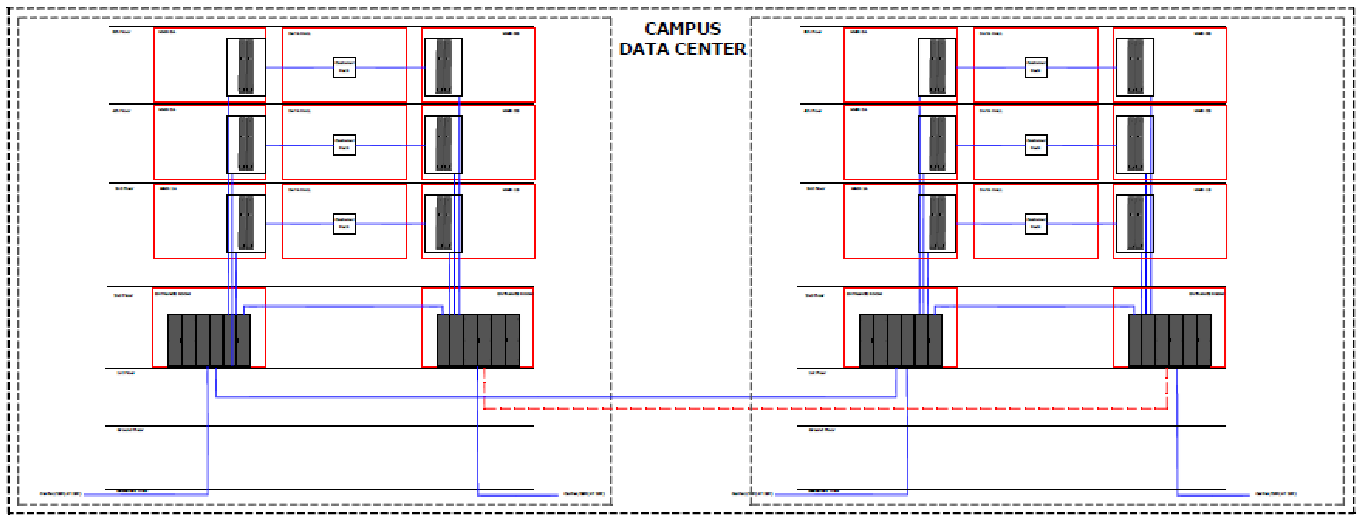


Application 3



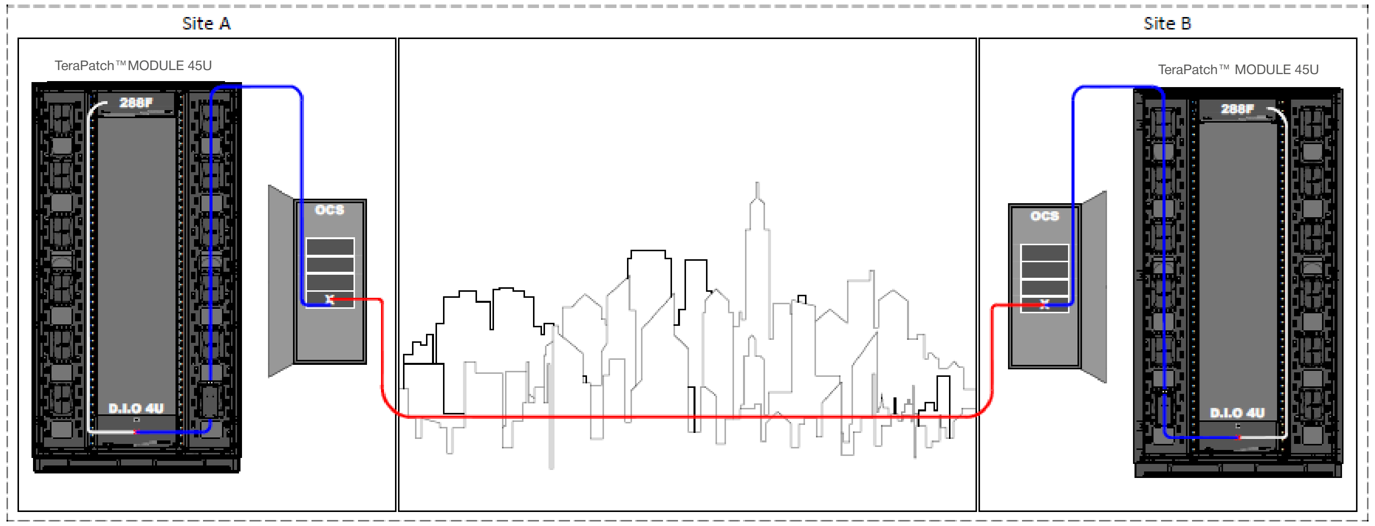
Campus data center

Due to the versatility of the TeraPatch™ Platform, it is possible to carry out an application aimed at routing and connecting fibers between DCs on the same campus. An example of this application is as follows.



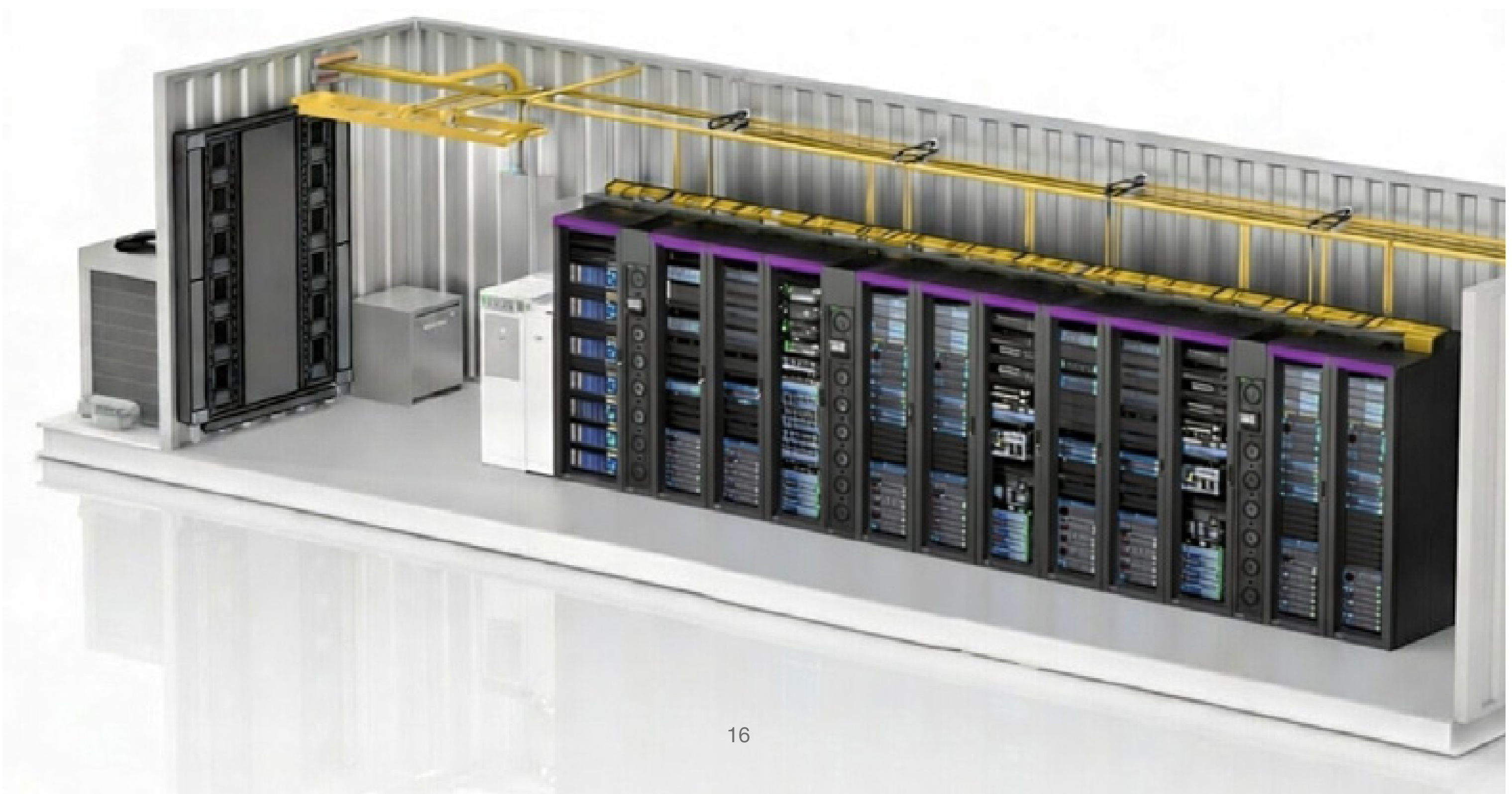
Data Center Interconnection

In a fiber routing scenario where the distance is high, the TeraPatch™ Platform also meets the necessary requirements for the connection to occur, showing that there are no barriers to its application. Here's an example.



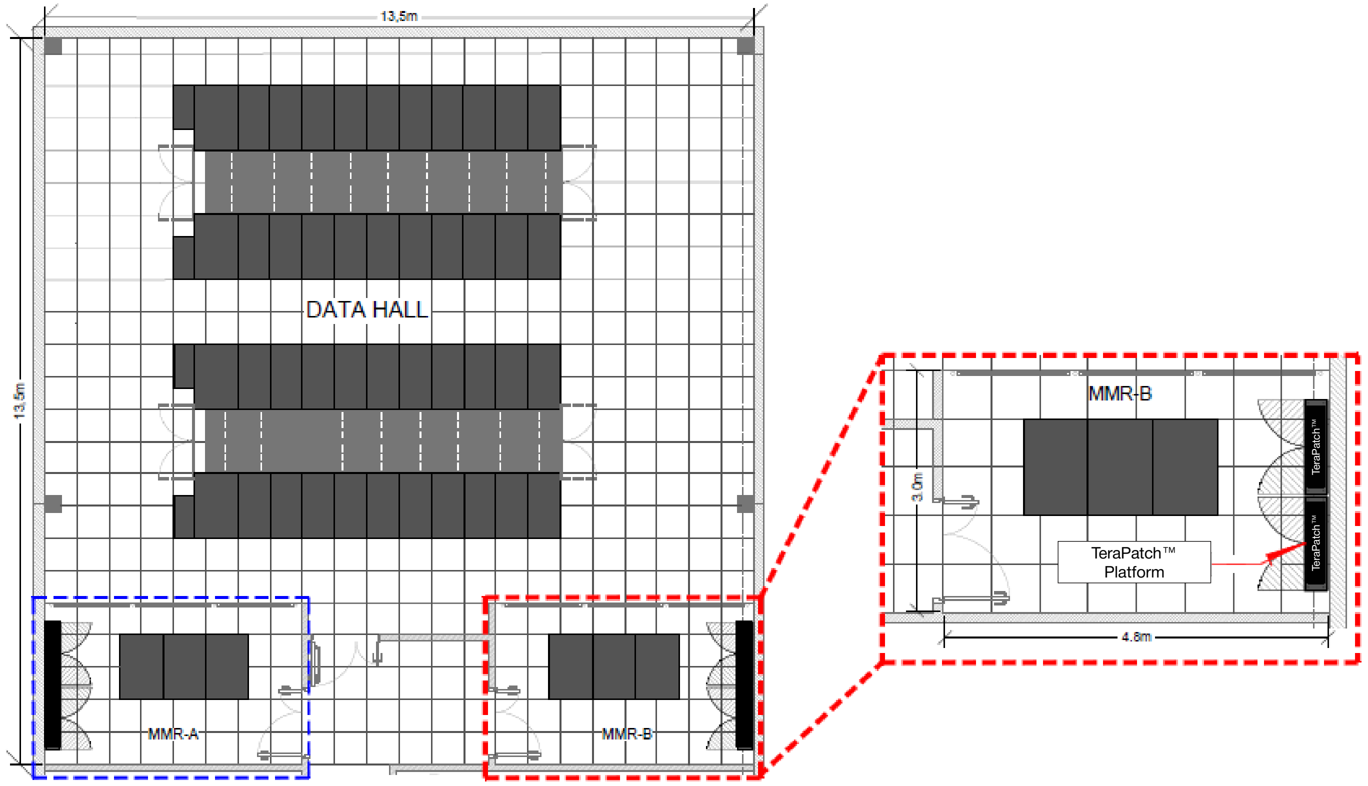
Containerized DC

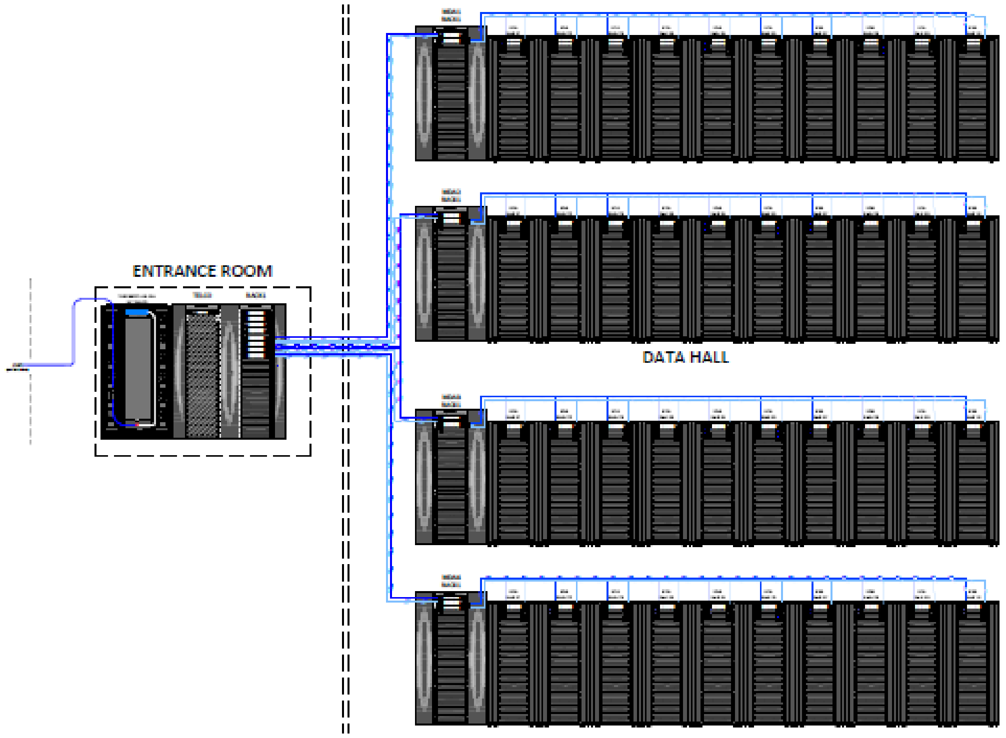
In addition to the previously exposed scenarios, there is also the use and application in data centers inside containers.
Here is an example:



DC Enterprise / ISP / Edge

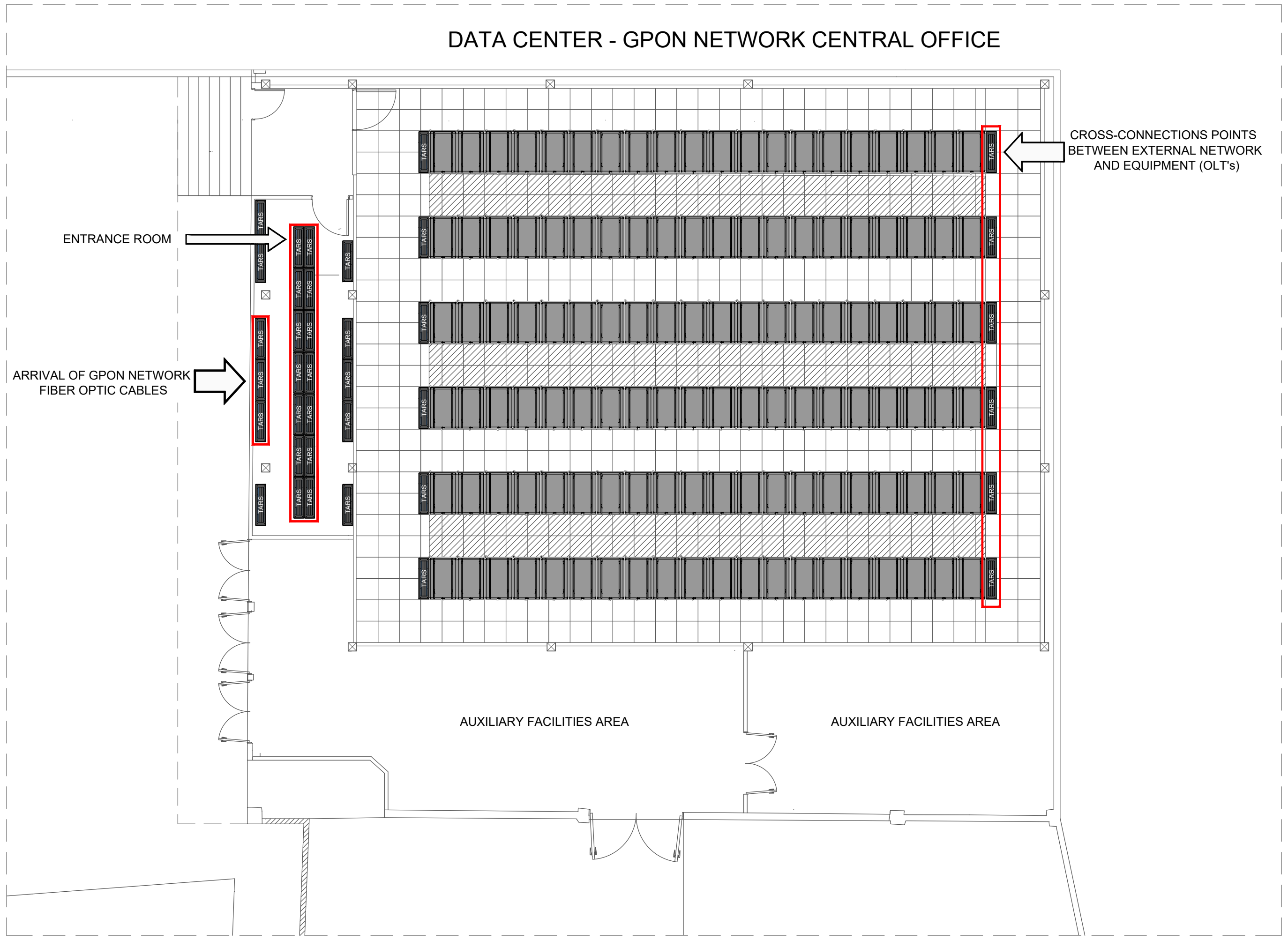
In the enterprise, ISPs (Internet service providers) and Edge segment, there are also scenarios for the application of the TeraPatch™ Platform. Here's an example:





DC - Central Office - GPON Network

One possibility of using the TeraPatch™ Platform is in data centers that serve a Central Office of GPON Networks. The TeraPatch™ Platform can be installed: in the Entrance Room of the data center at the arrival of optical cables from the external network, making the transition from the external to the internal environment; and in the data hall as an HDA, establishing cross-connection points between the external network and GPON equipment (OLTs), networking switches, and servers.



TeraPatch™ Platform Applications

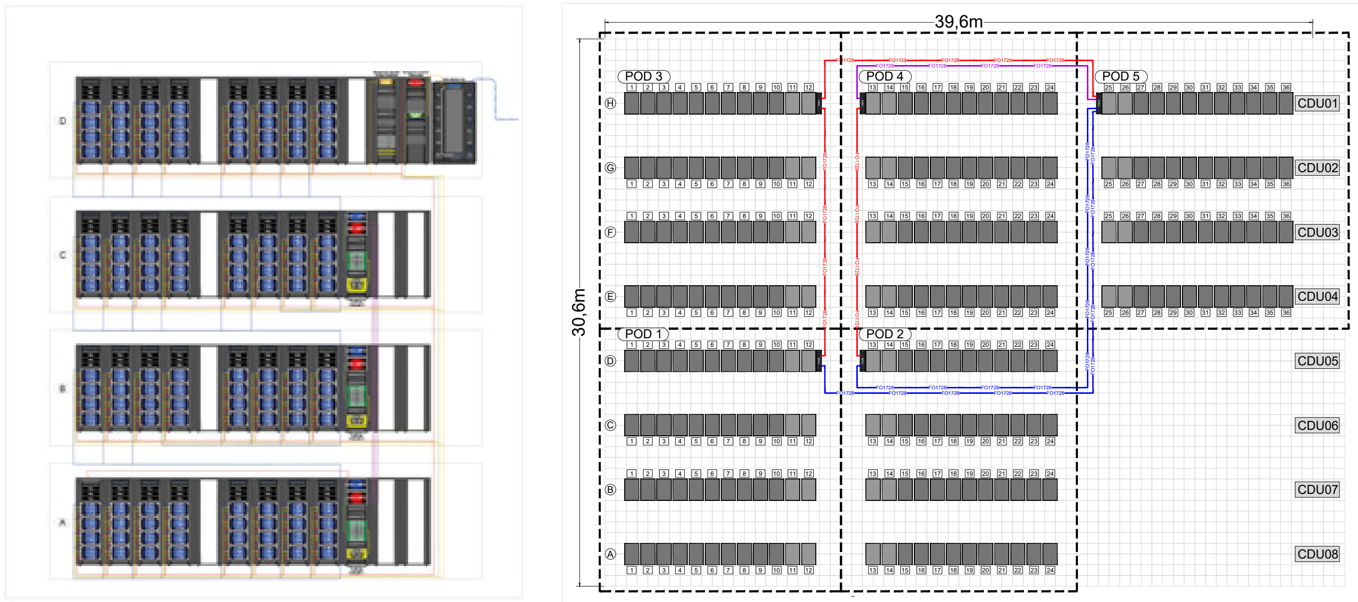
DC for AI - Artificial Intelligence

One possibility of using the TeraPatch™ Platform is in data centers for AI – Intelligence Artificial with the aim of interconnecting the PODs that contain the AI GPUs. As in this example to follow for the NVIDIA DGX H100 SuperPOD, THE TeraPatch™ Platform, COMBINED WITH THE structured cabling that interconnect the GPUs, could be installed as cross connection on each of the AI PODs establishing the optical interconnections of the computing, storage and in-band networks of SuperPOD at the Core level as shown in the illustration a follow. However, there is a need for an analysis and detailing of the reference architecture of the SuperPOD for complete adhesion of the suggested solution.

SuperPOD NVIDIA DGX H100

Source: NVIDIA

Structured Cabling Design for Interconnect GPUs and PODs

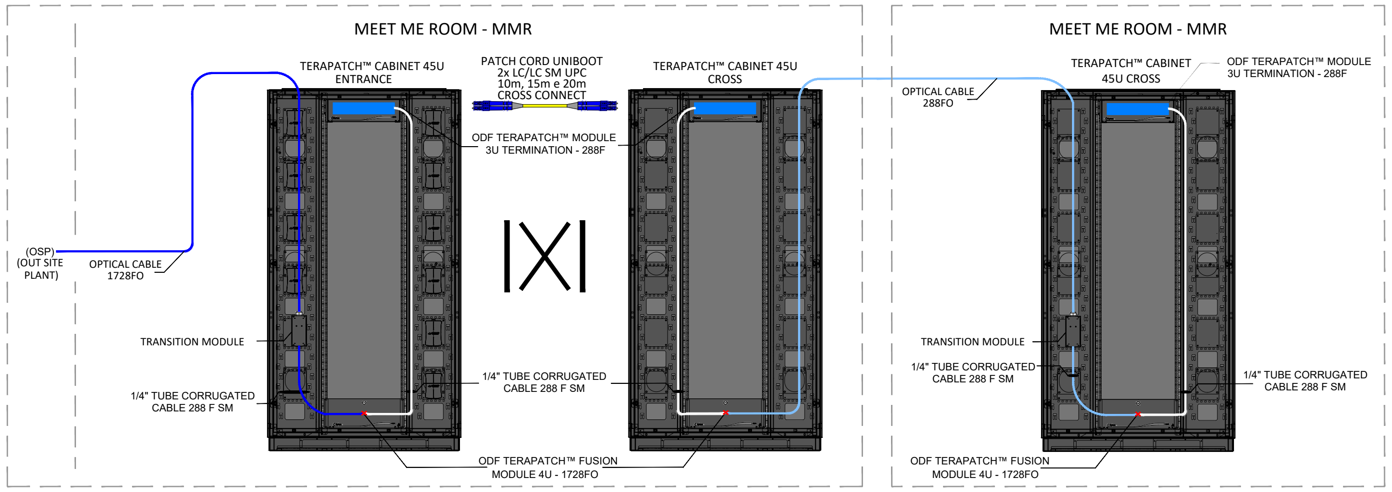


Source: Lightera

TeraPatch™ Platform Topologies

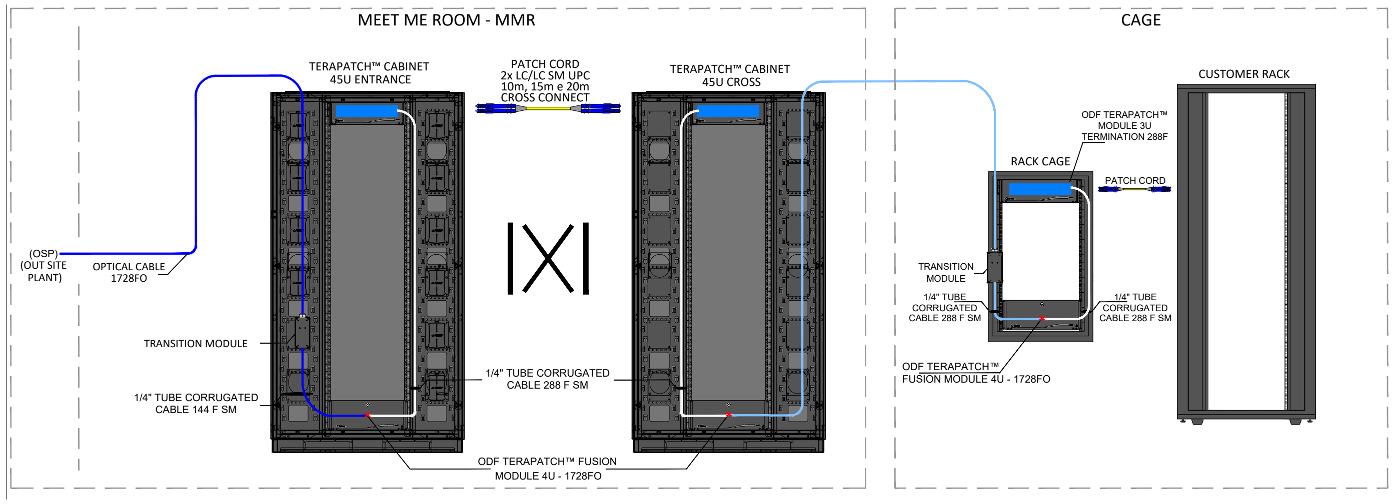
MMR-MMR

Among the various possible applications for the TeraPatch™ Platform, there is the option of the following topology of interconnection between Meet-Me-Room's using the cross-connect configuration. Here's an example.



MMR-CAGES

Among the various possible applications for the TeraPatch™ Platform, there is also the option of the following topology of interconnection between Meet-Me-Room's and the customer's Cages. Here's an example.

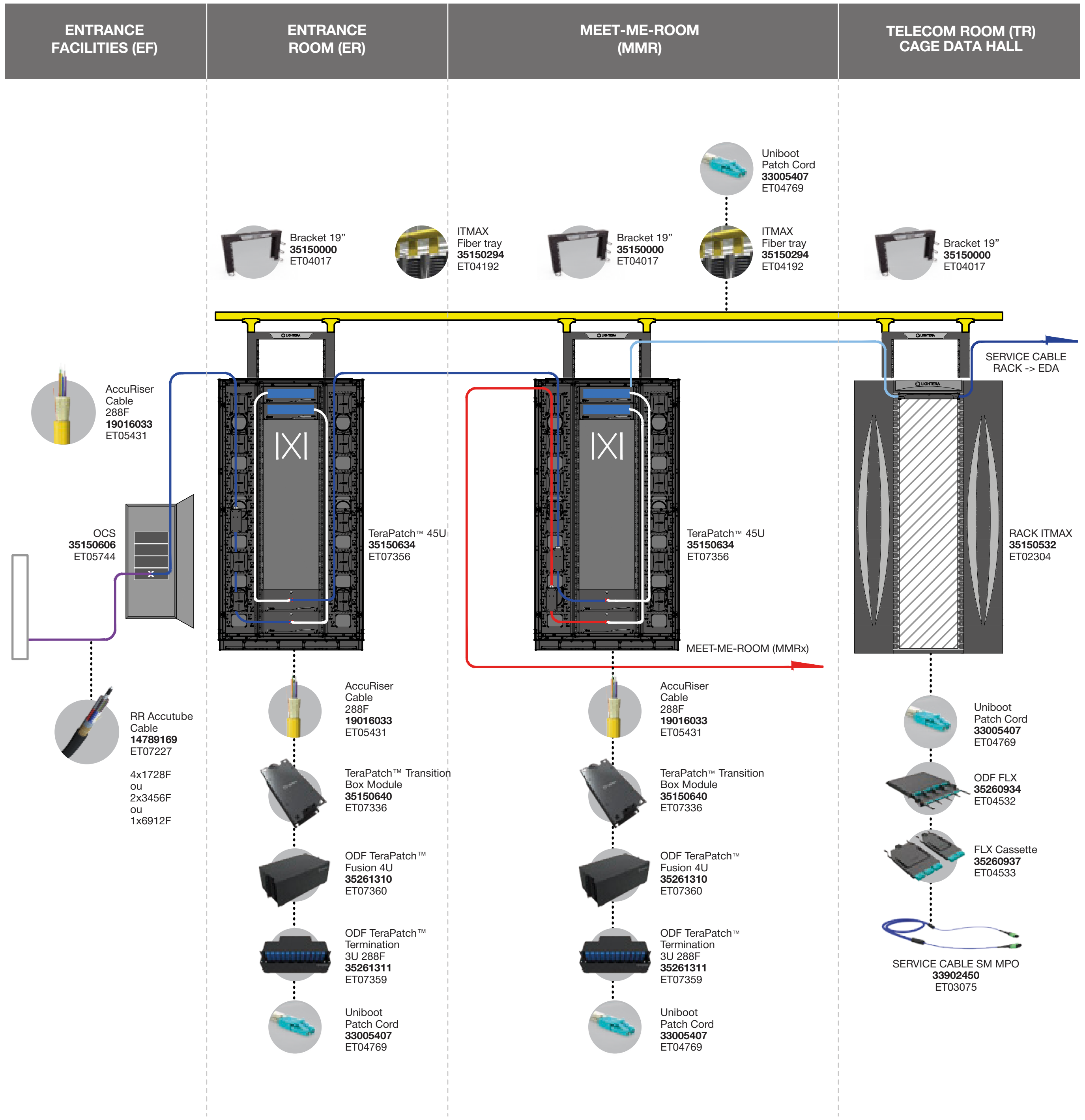


Diagrams

Block Diagrams

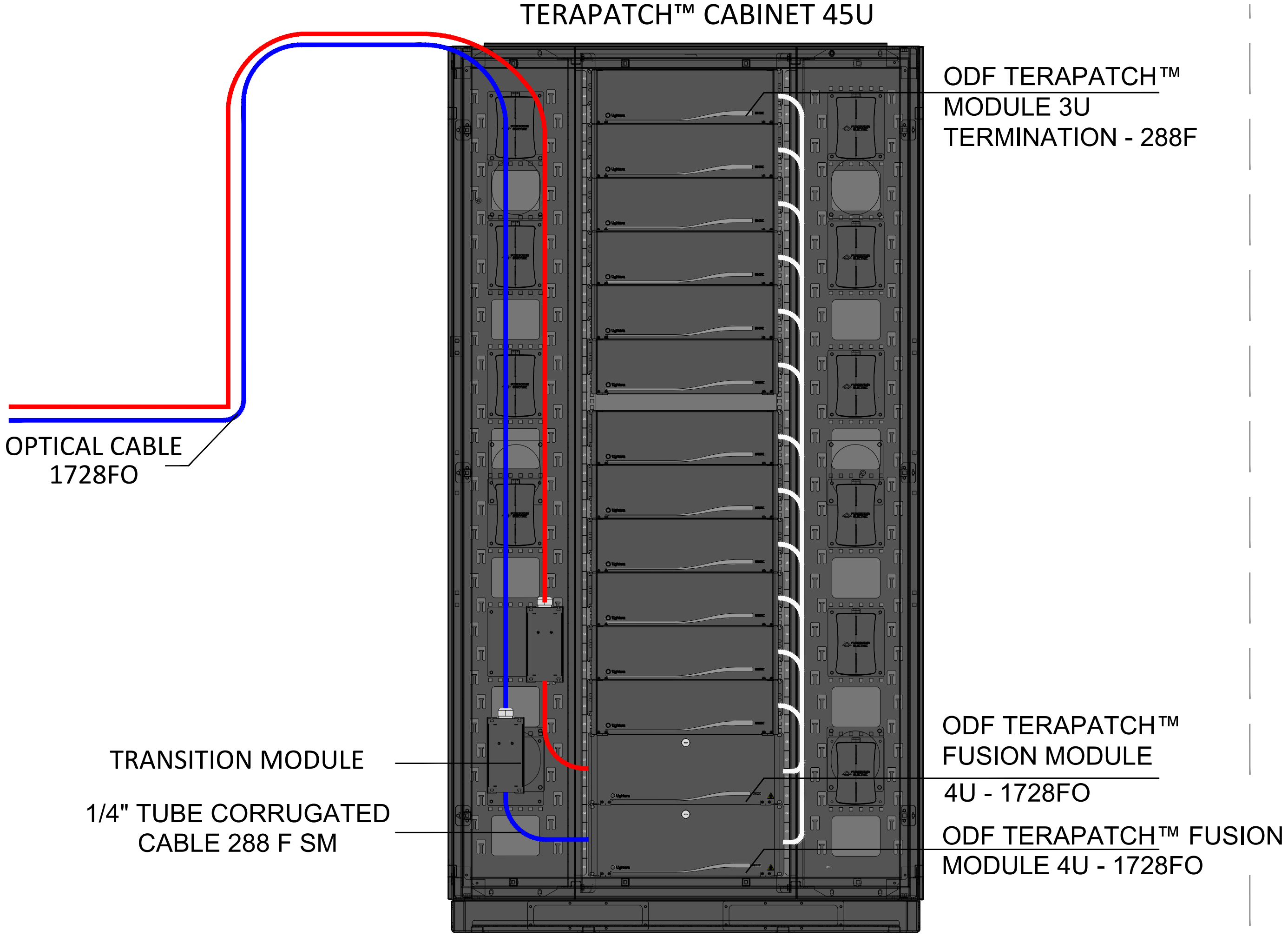
OCS / TeraPatch™ / ITMAX Racks

Seeking a better visualization of how the TeraPatch™ Platform fits with other products and applications, below is a block diagram showing from the fiber input in the DC to the fiber arrangement in the ITMAX line racks:



TeraPatch™ Cabinet Elevation

This is followed by a TeraPatch™ cabinet elevation of a complete TeraPatch™ with the maximum number of modules inside (two 4U fusion modules and twelve 3U 288F termination modules). In this way, it is possible to have a notion of quantities and utilization for possible projects.



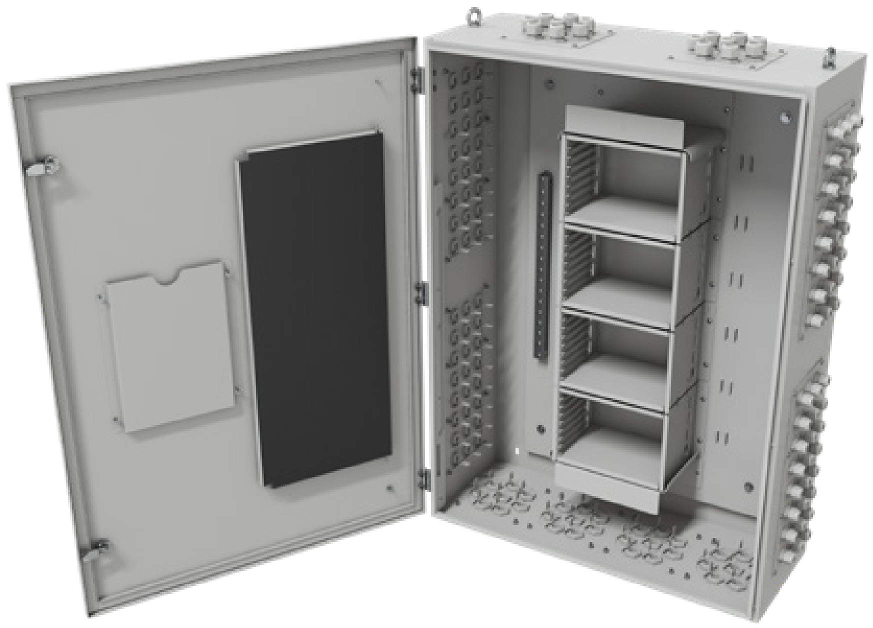
File Format Libraries

Aiming at the practicality of using the TeraPatch™ Platform in projects, some file formats will be available on Lightera's website to assist in the development and specification of solutions.

Consult our website: lightera.com

Lightera products complementary to the TeraPatch™ Platform

OCS



The TeraPatch™ Platform covers high-density applications, so it is important that there is the correct compatibility with complementary Lightera solutions. OCS (Optical Cabinet Splice), in this context, makes a difference since it has the function of providing easy fiber management and safe splice protection for transition between the external network and the data center. With this, the "arrival" of the cables to the TeraPatch™ can originate in the OCS office.

See the **Diagrams** chapter for more details on the Solution.

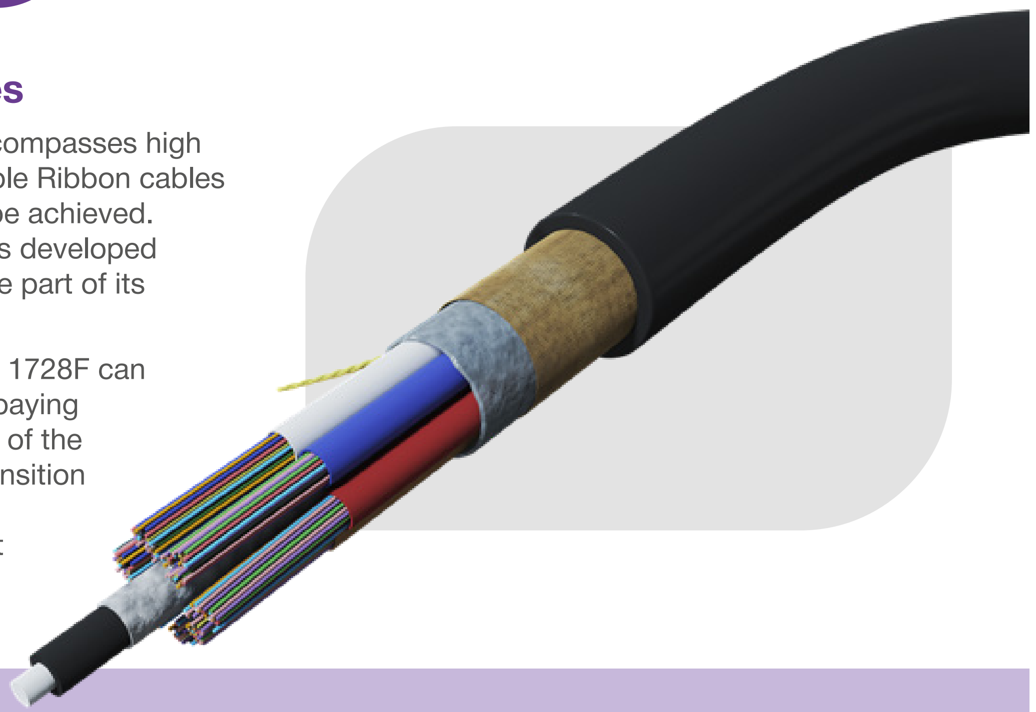
Lightera Part Number	Description	Technical Specification
35150606	OCS Basic Module - The OCS solution has accessories. For details, please refer to the Lightera website.	ET05744

Optical Cables

Rollable Ribbon Cables

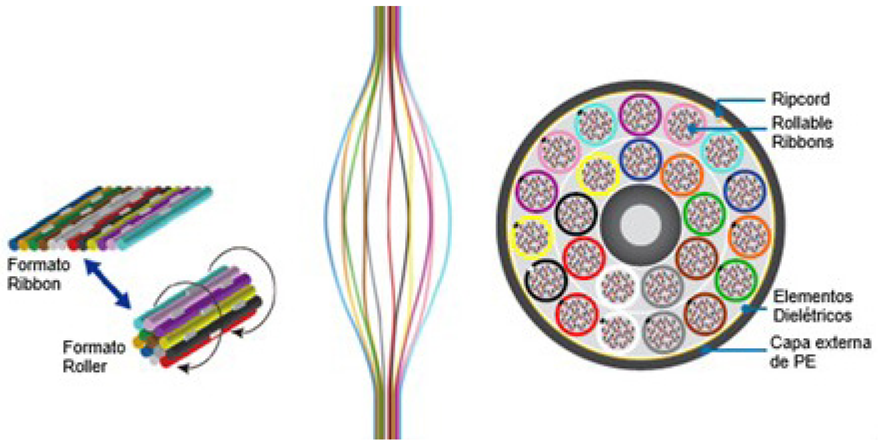
As the TeraPatch™ Platform encompasses high fiber density applications, Rollable Ribbon cables are essential for this density to be achieved. Because of this, the solution was developed so that high-formation cables are part of its topology.

Cables with a formation of up to 1728F can be installed inside the solution, paying attention to the accommodation of the cable inside the TeraPatch™ Transition Box Module and its respective formation of corrugated tubes at the "exit".

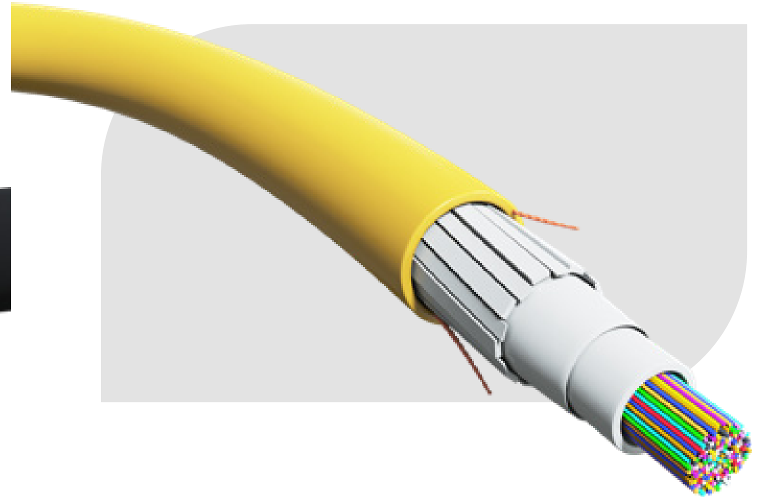


Lightera's AccuTube cables were developed to meet this growing demand for ultra-high-density solutions in data centers. Its flexible, compact design, adhering to national/ international standards and with **Rollable Ribbon technology** make it a great ally for highly complex projects. Here is an illustrative image:

In order to visualize the use of the cable in future projects, here is an explanatory and an example cross-section of the cable:

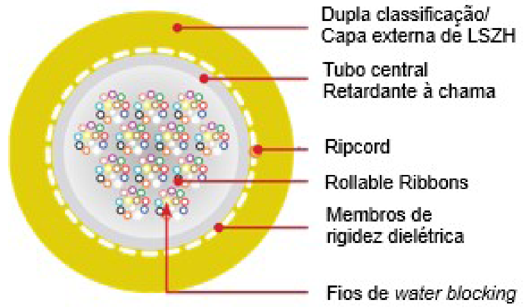


Lightera Part Number	Description	Technical Specification
19727058	AccuTube® 250 µm Rollable Ribbon Outdoor/Indoor Building Cable	ET07227
Upon Request	AccuTube 200 µm Rollable Ribbon Outdoor/Indoor Building Cable	ET07195



AccuRiser Cables

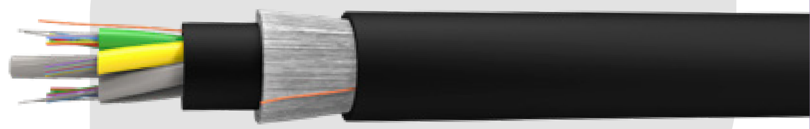
There is also the possibility that RR cables have only one set of cable formations, as is the case with the AccuRiser cable:

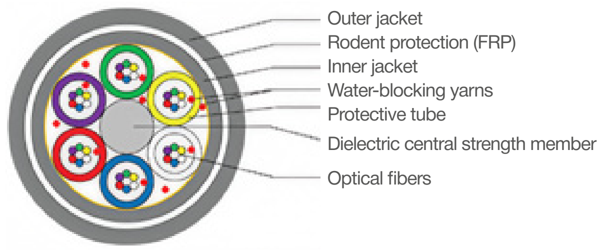


Lightera Part Number	Description	Technical Specification
Upon Request	AccuRiser™ 250 µm Rollable Ribbon Fiber Optic Cable	ET07222
Upon Request	AccuRiser™ 200 µm Rollable Ribbon Fiber Optic Cable	ET07221

Loose Tube Cable

Regarding cables with smaller constructions, there are also Loose Tube cables available in 72, 144, 288 fibers, among other configurations, as shown in the illustrative image below:





Código Lightera	Descrição	Especificação Técnica
17018101	Optical Cable CFOA-SM-DDR-S 72F G-652D TS (PFV) LSZH (ABNT CL)	ET02719
17718055	Optical Cable CFOA-SM-DDR-S 144F G-652D TS (PFV) LSZH (ABNT CL)	

Lightera products complementary to the TeraPatch™ Platform

Brackets 19”

In order to have complete compatibility between Lightera products, the TeraPatch™ Platform was designed and developed so that its use complies with the 19” brackets.

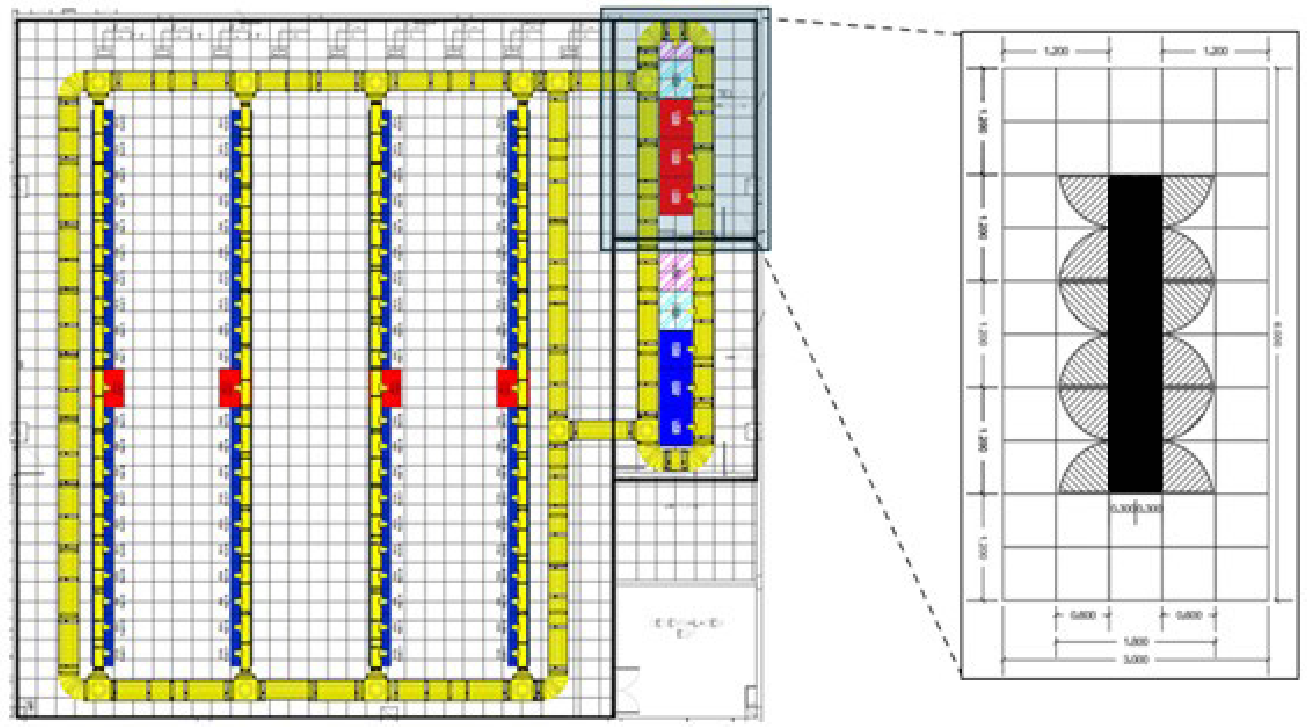
In this way, the fixing of the solution, together with the organization of the cables and the versatility of installation become a competitive attraction of the solution, giving greater robustness and adherence to the market.

Below is an illustration containing the 19” brackets in a TeraPatch™ Platform mount against the wall and another containing the product.

Lightera Part Number	Description	Technical Specification
35150009	Bracket 19”. Sale only with kit containing 2 units.	ET04017

ITMAX Raceway System

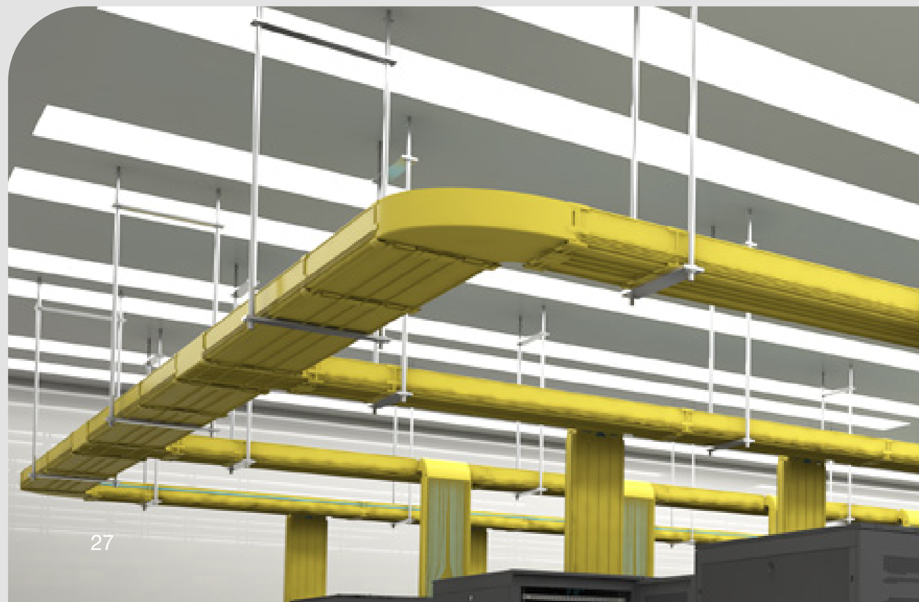
In the scenario of using the TeraPatch™ Platform, there is the possibility of taking advantage of Lightera’s ITMAX Raceway System. Here’s an example:



Lightera Part Number	Description	Technical Specification
35150131	ITMAX - Ducting System - 100mm main duct - without lid	ET04192
35150068	ITMAX - Ducting System - 220mm main duct - without lid	
35150134	ITMAX - Ducting System - 300mm main duct - without lid	
35150286	ITMAX - Ducting System - 600mm main duct - without lid	

It is important to have a sense of how the infrastructure solution behaves within the environment in which it is being planned. Because of this, here is an illustration of the **ITMAX raceways within a Data Hall.**

For more details on accessories, cconsult the ITMAX Raceway System Guide



ITMAX Racks

As with OCS, the TeraPatch™ Platform is fully compatible with the **ITMAX** line, making life easier for those who want to carry out a complete project with Lightera products. For this, pre-connectorized optical cords and cables from TeraPatch™ can be used for whatever is needed inside the racks. Here is an illustration of the rack.

As will be shown below, there are topology suggestions to consider in a possible project.

Lightera Part Number	Description	Technical Specification
35150531	Open Rack 2P 19" 45U ITMAX	ET02295
35150106	ITMAX Vertical Cable Manager 200mm - Single Door	ET03069
35150521	ITMAX Side Cover For Vertical Manager - Single Door	ET02323
35150409	ITMAX Plastic Spool (5 Pieces)	ET02327
35150107	ITMAX Vertical Cable Manager Between Racks 315mm - Single Door	ET03068
35150255	ITMAX Grounding Bar	ET02325
35150405	ITMAX Up And Bottom Rack Tray	ET02313

FLX Cassettes

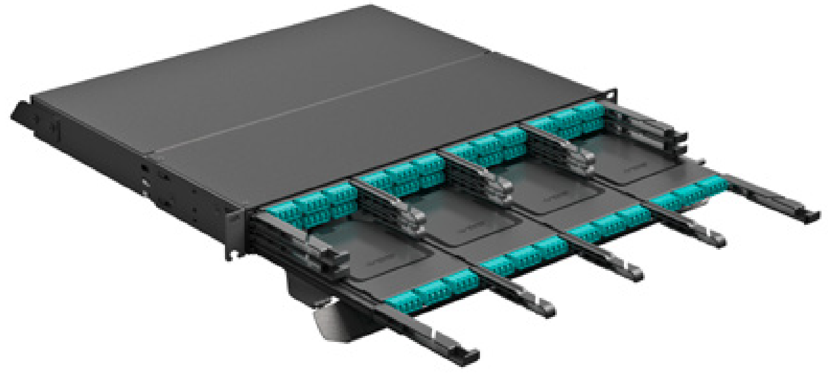
To be compatible with the FLX line of ODFs, you have the **FLX Cassettes**. It is a factory-assembled optical module with MPO/MTP optical adapter of 08 fibers (Base 8) or 12 fibers (Base 12) of the female type (without guide pin) on the back, and duplex LC optical adapters on the front.

The **FLX Cassette** is suitable for high-density optical fiber environments in plug and play systems. It allows:

- ✓ Flexibility and modularity, with ease of expansion without quality degradation;
- ✓ Quick and easy installation and reconfiguration;
- ✓ Simple handling.

Lightera Part Number	Description	Technical Specification
35260941	ODF Cassette FLX Premium 08F SM BLI G-657A LC-UPC/MPO8-APC(F) Type B Straight	ET04533
35260942	ODF Cassette FLX Premium 08F SM BLI G-657A LC-UPC/MPO8-APC(F) Type B Reverse	
35260937	ODF Cassette FLX Premium 12F SM BLI G-657A LC-UPC/MPO12-APC(F) Type B Straight	
35260938	ODF Cassette FLX Premium 12F SM BLI G-657A LC-UPC/MPO12-APC(F) Type B Reverse	

FLX ODFs



FLX ODFs, in conjunction with ITMAX racks, can be the continuity of the interconnections that originate from the TeraPatch™ Platform.

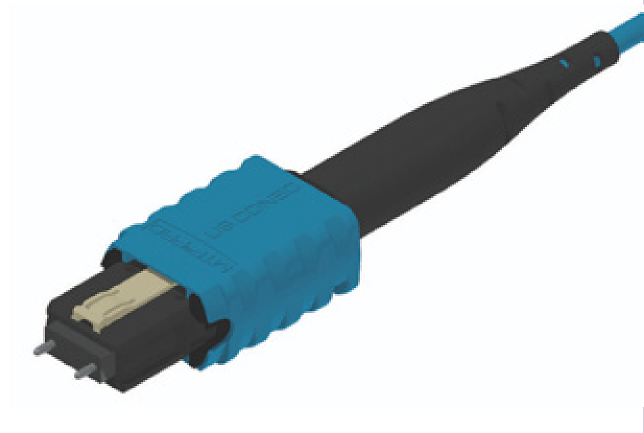
The FLX line represents a modern, modular approach to optical distribution in data centers, with a focus on high density, flexibility, scalability, and ease of installation. By opting for FLX ODFs, the designer and the end customer gain a solution that is standardized, efficient, and compatible with the new connectivity and expansion requirements.

The structure of FLX ODFs includes rails for fitting the cassettes, a front organizer for the entry and routing of the optical cords, and an area for accommodating excess fibers — an important aspect to maintain a clean and orderly cabling, essential in high-density environments.

For environments that demand high fiber density, expansion flexibility, and efficient organization, FLX ODFs offer scalability without rework. With pre-assembled modules and modular system, it becomes simple to add terminals or expand capacity as demand grows. In addition, it is possible to save space and better organization, since the high density of ports allows you to concentrate a large amount of fibers in a small rack space, reducing occupation and facilitating the physical management of the infrastructure.

Lightera Part Number	Description	Technical Specification
35261061	ODF Modular FLX 1U - Basic Module - Base 8	ET04532
35260934	ODF Modular FLX 1U - Basic Module - Base 12	

Trunk Cable

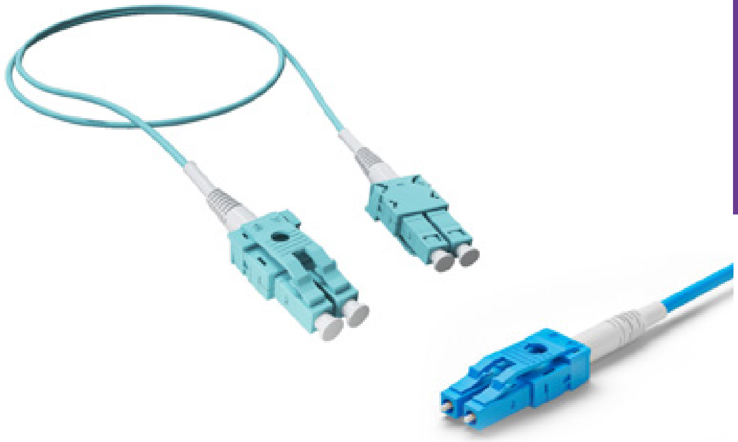


Circular construction optical cable of the totally dry type ("loose tube"), pre-connectorized at the factory with high performance optical connectors, for use in internal or indoor/external network environments. Available mounted on the two ends with MPO optical connectors.

Lightera Part Number	Description	Technical Specification
33901195	Trunk Cable Pre-Terminated 12F SM BLI G-657A2 MPO12-APC(M)/ MPO12-APC(M) 0.8D3/0.8D3 15.0m - UT - LSZH - Blue - Type B - Premium	ET03779

Lightera products complementary to the TeraPatch™ Platform

Optical Patch Cords



For the TeraPatch™ Platform, Lightera recommends the use of Uniboot cords for the reasons of:

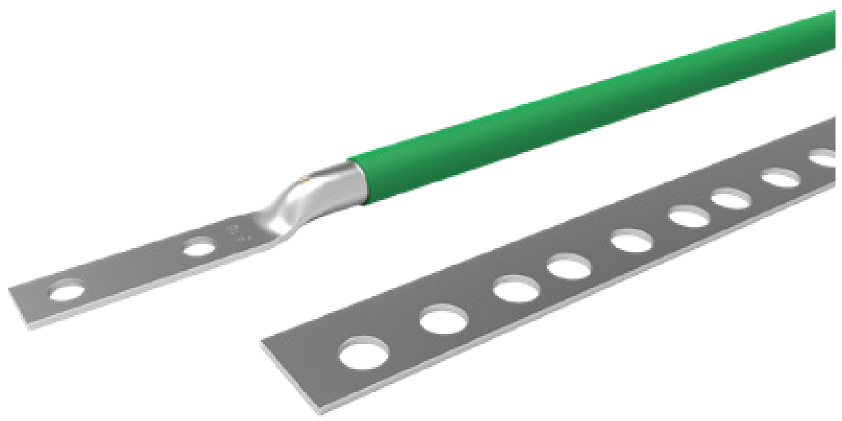
- ✓ Density, as it reduces the volume of cables and, consequently, takes up less space;
- ✓ Organization and maintenance;
- ✓ Fast, tool-free polarity reversal;
- ✓ Easier installation and organization in vertical and horizontal guides.

Optical cords play a central role in the construction of reliable, organized channels that are compatible with increasingly compact infrastructures. The evolution of transmission solutions and the need to optimize the use of physical space make the choice of optical cord a point of attention for DC.

Among the various existing cord configurations, the LC Duplex Uniboot features adherence to the TeraPatch™ Platform, along with the TeraPatch™ ODF 3U Module 288F Termination. Lightera's optical cords support the main applications according to IEEE 802.3, ANSI T11.2 (Fibre Channel) and ITU-T-G-984 standards.

Lightera Part Number	Description	Technical Specification
33004745	Duplex Optical Patch Cord SM BLI G-657A2 LC(UBX)-UPC/LC(UBX)-UPC - 3.0m - LSZH - Blue (A - B) - Premium	ET04769

Grounding Bar



Made of copper coated with electrolytic tin which provides Rack binding to the site's grounding system. Supplied with screws and cable electrical linkage being compatible with TeraPatch™ Platform enclosures and ITMAX Racks.

Lightera Part Number	Description	Technical Specification
35150255	ITMAX Grounding Bar	ET02325

3 Attachments

The following annexes constitute a complementary collection of information, technical references and support resources developed specifically to support and enhance complements to projects that implement Lightera's TeraPatch™ Platform.

This part of the Application Guide has been structured with the aim of offering content of a generic and related nature, applicable to different scenarios of use of the TeraPatch™ Platform. Here you will find:

- ✓ **Supplementary Information:** Technical details, topologies, diagrams, and auxiliary references that expand the understanding of the concepts presented in the main body of the guide.
- ✓ **Regulatory Documentation:** References to standards, guides, websites, standards, and regulations relevant to the safe and compliant implementation of the solution.

Attachments are modular and self-contained query resources. You can access them according to the specific needs of your project, without the obligation to follow a linear sequence. Each attachment is clearly labeled with its theme and scope of application, allowing you to quickly locate the desired information.

Scope and Applicability

Importantly, the content in this section reflects some of the consolidated best practices and typical implementation scenarios for structured cabling infrastructures. Although comprehensive, this material is of a guiding and generic nature. Projects with specific requirements, customizations, or particular constraints should be validated in conjunction with Lightera's technical team, ensuring that the TeraPatch™ Platform is fully aligned with your use case objectives.

Technical Support

If you identify gaps in information, have questions about the applicability of an annex to your specific project, or need additional technical clarifications, do not hesitate to contact Lightera's Applications and Products Engineering through the support channels provided.

The following attachments are your allies in the successful implementation of the TeraPatch™ Platform. Explore, refer and apply with confidence.

Annex I

Backbone Topology in Data Centers

Design best practices

A data center backbone should be designed to provide scalability, operational continuity, high performance, and flexibility for expansion, regardless of the cabling topology adopted. This includes cabling topologies to serve network architectures such as Spine-Leaf and Three-Tier (Core, Aggregation, and Access). In any of them, a fundamental premise is to avoid single points of failure (SPOF), ensuring logical and physical redundancy through different physical paths and equipment in pairs.

The project must consider the progressive growth of data traffic and the need for horizontal scalability, predicting excess capacity of ports, fibers and optical modules. The use of high-density structured cabling, ultra-low-loss connectors, and single-mode fibers tends to increase network life and facilitate migration to higher speeds (40/100/400/800G/1.6T).

In addition to physical infrastructure, good design practices, documentation, clear route identification, change management, and continuous network monitoring are key to maintaining operational predictability. The chosen topology must be aligned with the application profile, traffic patterns (north-south, east-west), applicable technical standards, and latency requirements, ensuring reliable communication between servers, storage, external services, and cloud.

Environments covered

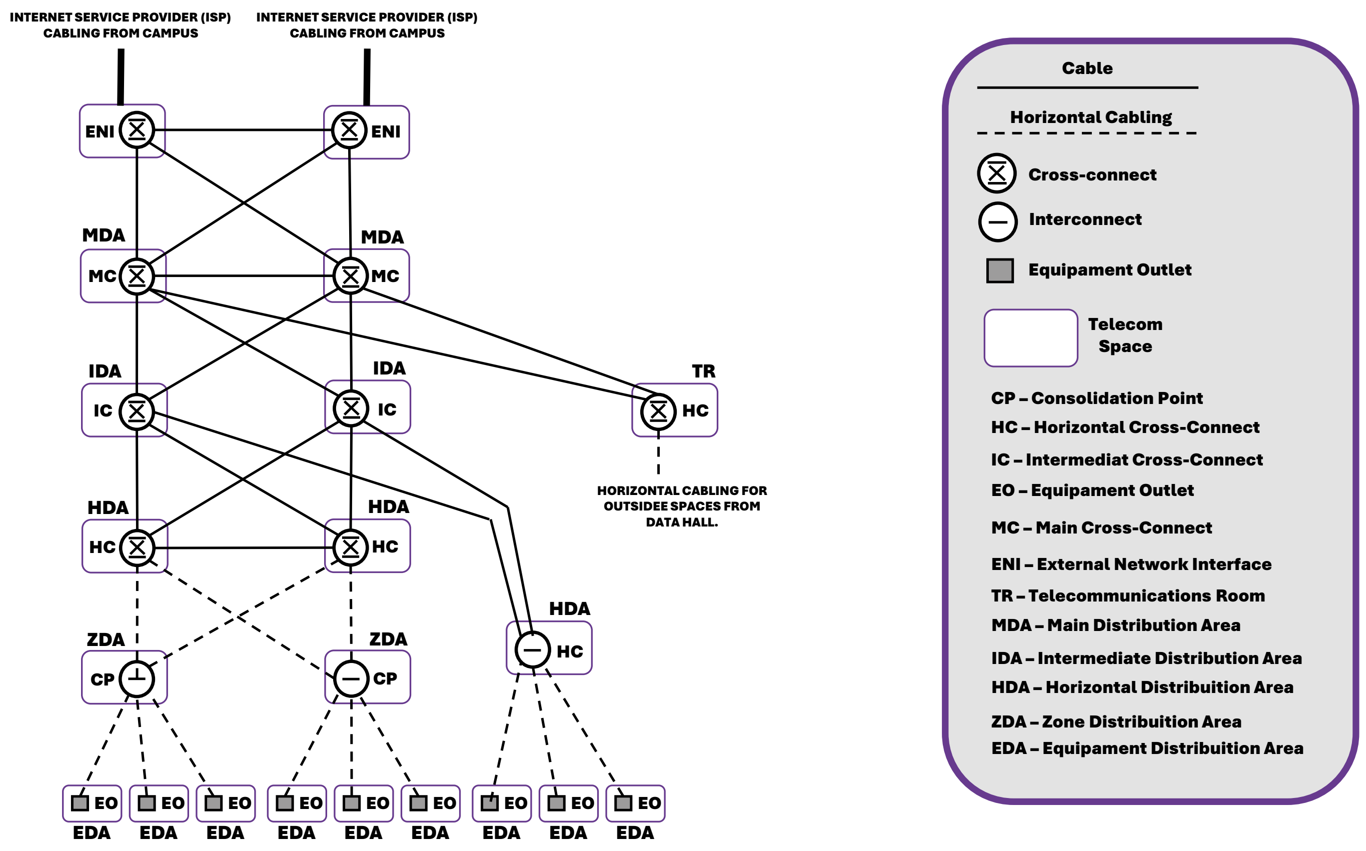
The backbone topology in a data center acts as the link between the various domains that make up the infrastructure. In access and aggregation environments, the backbone connects the switches that serve the server and storage racks to the higher distribution or core layers, ensuring that traffic flows in a stable and predictable manner.

In the main equipment rooms, where core switches, routers, and edge devices are concentrated, the backbone assumes a strategic role by integrating the data center with corporate networks, carriers, and external services (including cloud and internet). In distributed or multi-site data center scenarios, the backbone extends beyond the physical campus, encompassing metropolitan or inter-regional optical links that enable data replication, contingency, and workload orchestration.

Thus, the backbone is not limited to a single environment or level of architecture: it permeates from the access level to the external edge of the network, supporting communication between servers, storage systems, cloud environments, WAN networks, and critical services, ensuring performance, resilience, and operational continuity in any data center model.

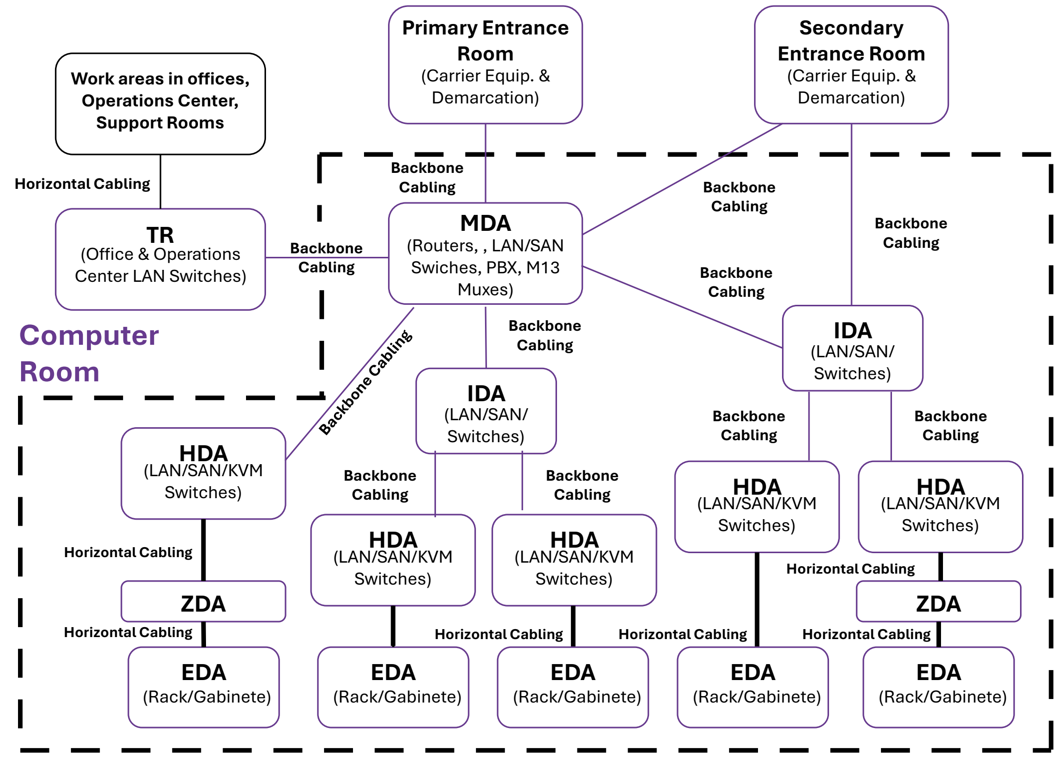
The ANSI/TIA-942 standard recommends the implementation of a hierarchical star cabling topology, with the provision of different distribution areas for the cross-connects and interconnections of structured cabling. This standard defines five different areas of cross-connection and/or interconnection:

- ✓ **MDA - main distribution area;**
- ✓ **IDA - intermediate distribution area;**
- ✓ **HDA - horizontal distribution area;**
- ✓ **ZDA - distribution area by zone;**
- ✓ **EDA - equipment distribution area.**



These distribution areas represent, in a generic way, a network composed of racks and/or cabinets to the main area where routers, switches, and AI clusters will be located. The ANSI/TIA-942 standard also provides guidance on redundancy definitions (paths, spaces, interconnects, components, and equipment), classifying them into four levels known as availability classifications called: Rated. The classification Rated 1 is the lowest level with the least redundancy. The classification Rated 4 provides the most redundancy in a data center's structured cabling and is typically implemented in HPC data centers.

When it comes to structured cabling topologies, the standard addresses both backbone cabling and horizontal cabling, as illustrated in the following diagram. Each of the distribution areas, represented in the identified rectangles, is a cross-connection area or interconnection that contains passive connection hardware (patch panels and/or ODF's).



Annex II • Technical Standards

Structured Cabling

International

ISO/IEC 11801-1 - Information Technology – Generic Cabling for Customer Premises – Part 1: General requirements

This standard defines design and performance requirements for cabling in general, covering topologies, maximum distances, cable classes and connectors. The goal is to ensure standardization, high availability, and flexibility for expansions while maintaining consistent performance and organization.

Brazilian

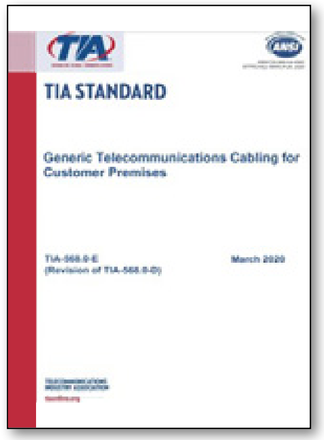
ABNT NBR 14565 - Structured cabling for commercial buildings

National version equivalent to ISO/IEC 11801. Establishes requirements for structured cabling in commercial buildings, including cable categories, maximum distances, and distribution topologies.

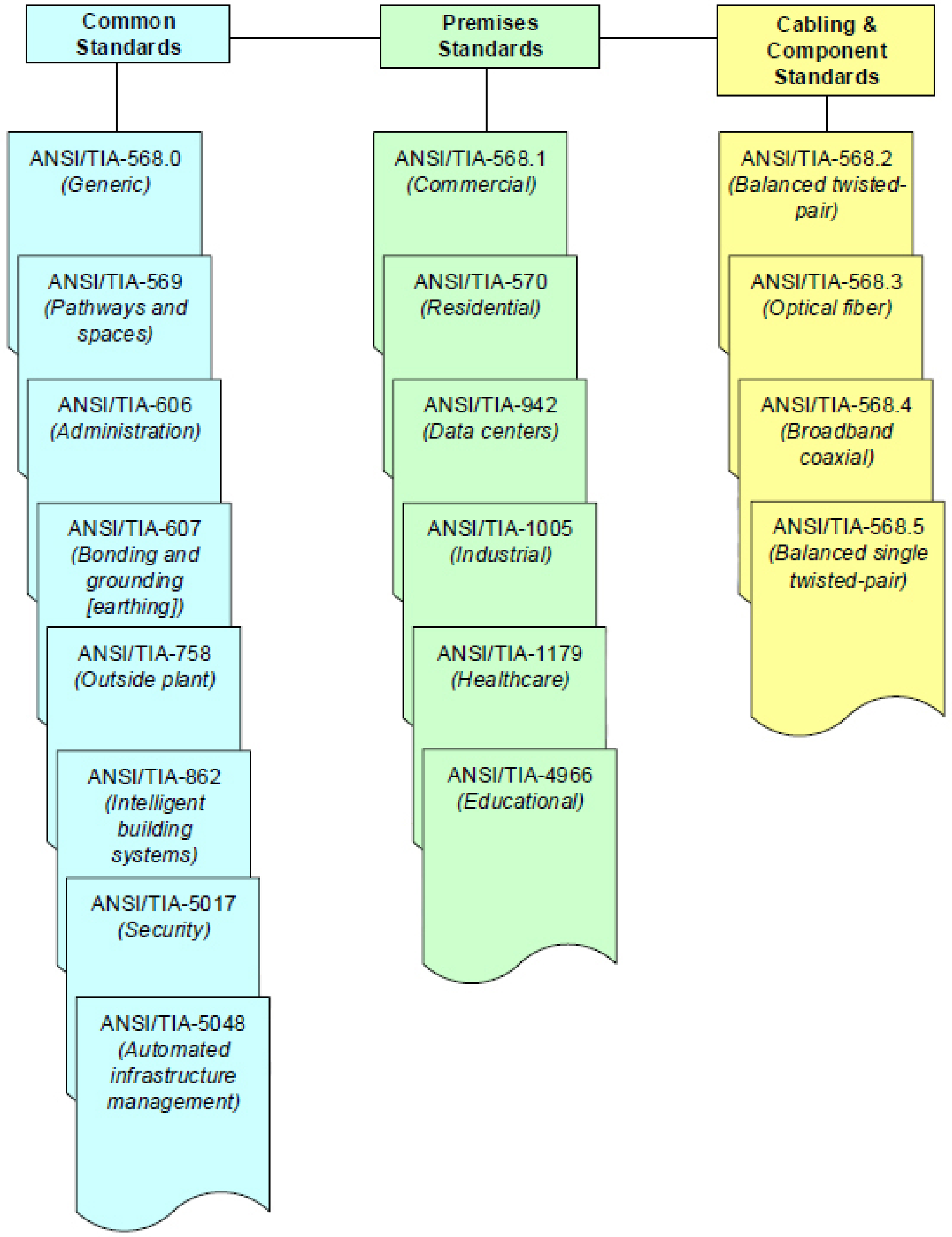
North American

TIA-568

The TIA-568 (Telecommunications Industry Association) series of standards defines structured cabling requirements for telecommunications networks in commercial buildings and data centers, ensuring standardization, interoperability, and performance.
The base standard, TIA-568, has evolved over the years and has unfolded into different parts that address complementary aspects of the cabling system.
Together, the TIA-568 family variations provide a complete technical framework that guides from design and installation to testing and maintenance of network infrastructures, promoting global standardization, high availability, and scalability in modern communication systems.



In addition to the TIA-568 series standards, there is also TIA-569 for specifying routes and spaces of telecommunications infrastructure, TIA-606 for defining standards for administration and documentation of cabling systems, and TIA-607 for establishing requirements for the system of linking and grounding telecommunications infrastructure.
To facilitate the understanding of the functioning of the standards and their respective scopes, here is an illustration from TIA-568 itself that shows the correlations between the different parts of the standard.



Data Center

International

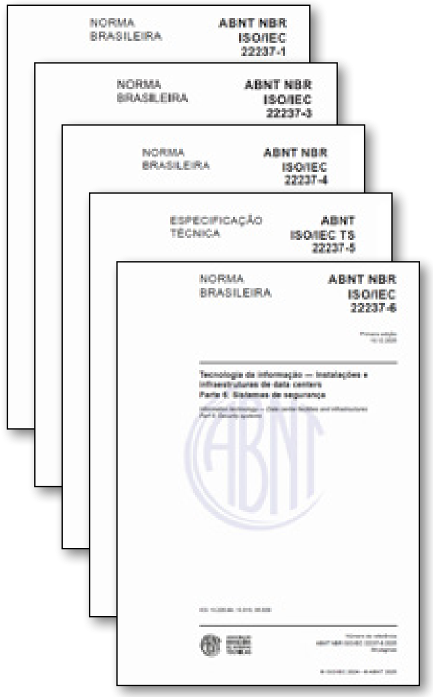
ISO/IEC 11801-5 - Information Technology – Generic Cabling for Customer Premises – Part 5: Data center (anteriormente ISO/IEC 24764).

This standard defines design and performance requirements for cabling within data centers, covering topologies, maximum distances, cable classes, and connectors. The objective is to ensure standardization, high availability and flexibility for expansions, maintaining performance and organization consistent with critical environments.

Brazilian

ABNT NBR ISO IEC 22237 - Information Technology - Facilities and Data Center Infrastructures.

ABNT NBR ISO IEC 22237 specifies the requirements and recommendations to support the various parts involved in the design, planning, procurement, integration, installation, operation and maintenance of the Facilities and infrastructures within data centers.



North American

TIA-942 - Telecommunications Infrastructure Standard for data centers.

Specific standard for data centers, detailing physical layout, network topology, redundancy (Rating), cabling requirements, power, air conditioning and security. It is one of the most used as a reference for the design and implementation of data center infrastructures.

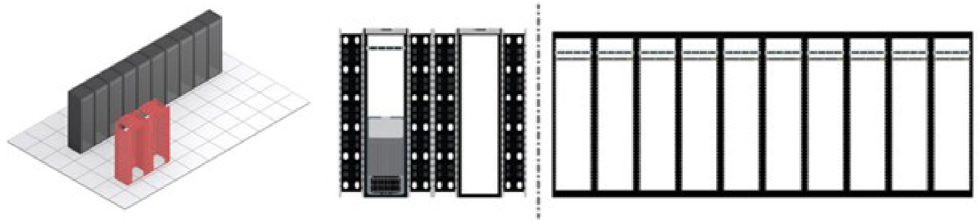
Annex III • Types of cabling topology

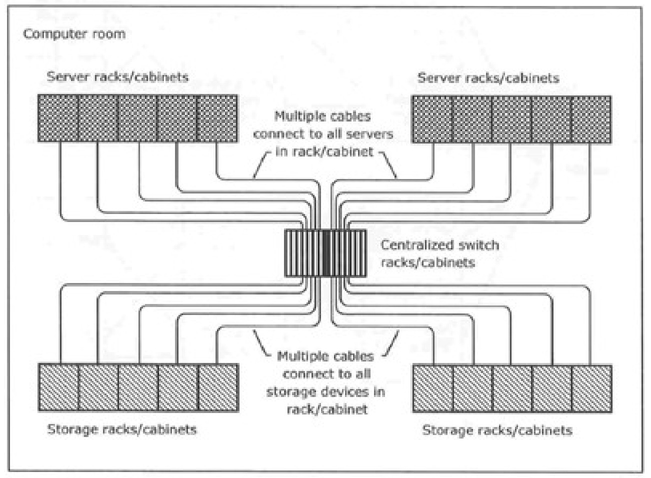
Currently, there are three main cabling topologies in application within data centers with their own specific characteristics. In HPC data centers, two or even all three topologies are typically applied simultaneously in the same facility.

Centralized Topology

In a centralized topology, all core switches are located in a specific area of the data hall. Cabling infrastructure interconnects all servers and storage equipment to centralized switches.

Of the three topologies, the centralized one uses the largest amount of cabling. The advantages of this topology include centralized access to all data hall switch connections and equipment cost savings due to the need for fewer switches than the other topologies.





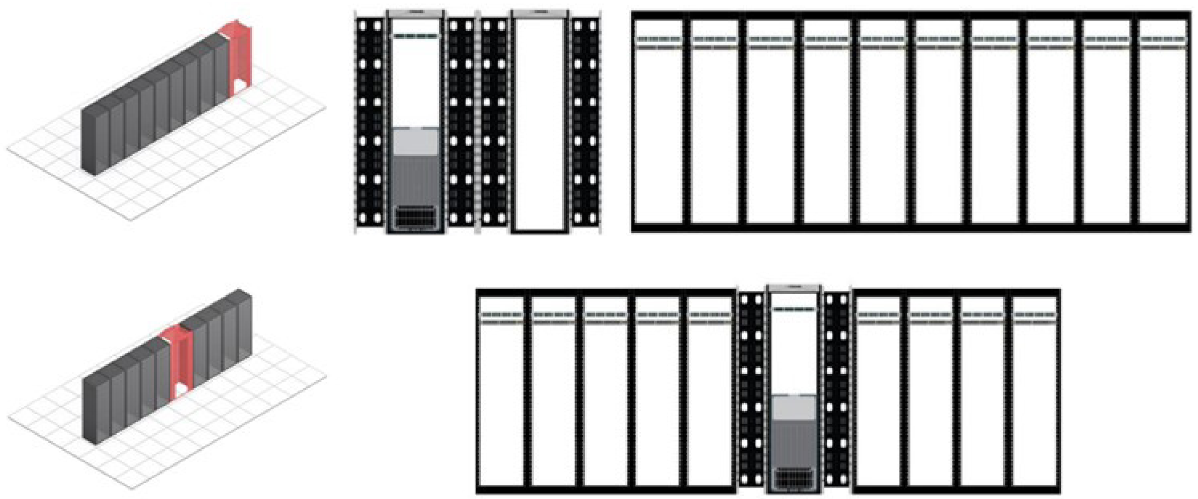
Source: ANSI/BICSI 002

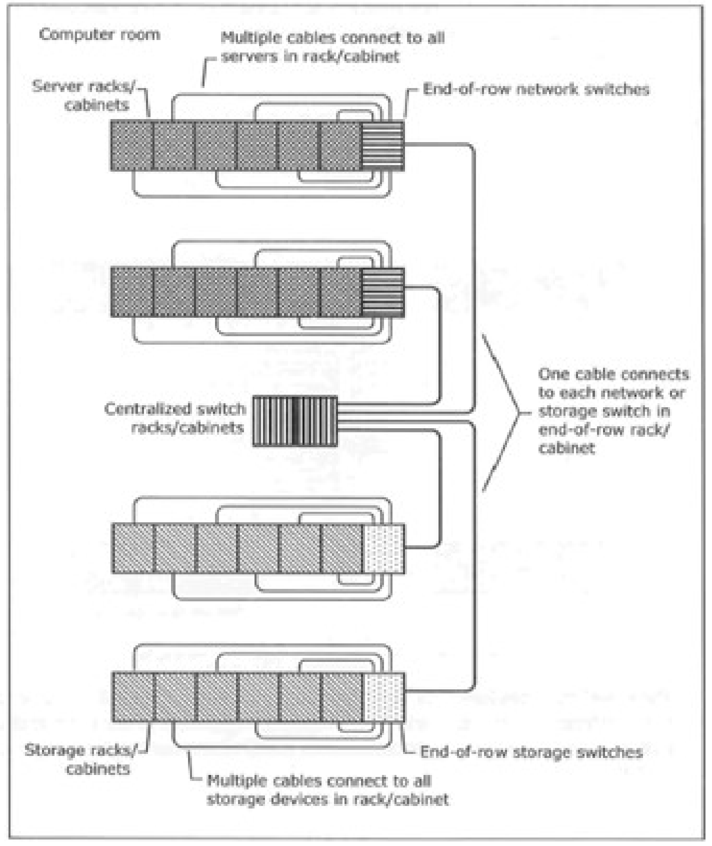
End-of-Row / Middle-of-Row Topology

In an end/mid-queue topology, two levels of switches are implemented.

The servers and storage devices in each rack row are bound to one or more switches installed in a rack or cabinet at the end or middle of the rack row. All of these end/middle queue switches are then connected to one or more centralized switches to enable communications between all devices in the data hall.

The end/middle of queue topology uses less cabling than the centralized topology, because the switches connected to the server and storage devices are located closer to these devices than the centralized model. Only a single cable is required to connect each end/mid-queue switch to a centralized switch. However, a greater number of switches must be installed and managed in the data hall with this topology than in the centralized topology.



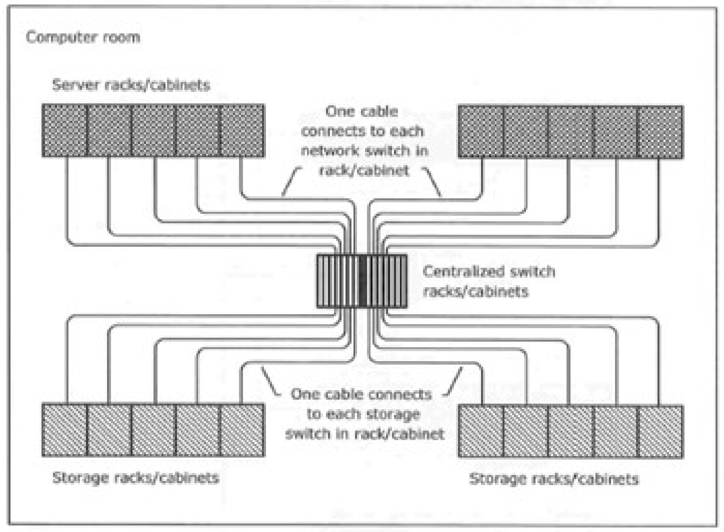


Source: ANSI/BICSI 002

Top-of-Rack Topology

In a top-of-rack topology, each rack or cabinet containing servers and storage devices is also equipped with at least one switch. Each of these switches is then connected to one or more centralized switches to enable communication between all devices in the data hall.

Top-of-rack topology uses the least amount of cabling because only a single cable is required from a centralized switch to the switch in each rack or cabinet containing servers and storage devices. However, switches must be installed and managed in each rack or cabinet in the data hall.



Source: ANSI/BICSI 002

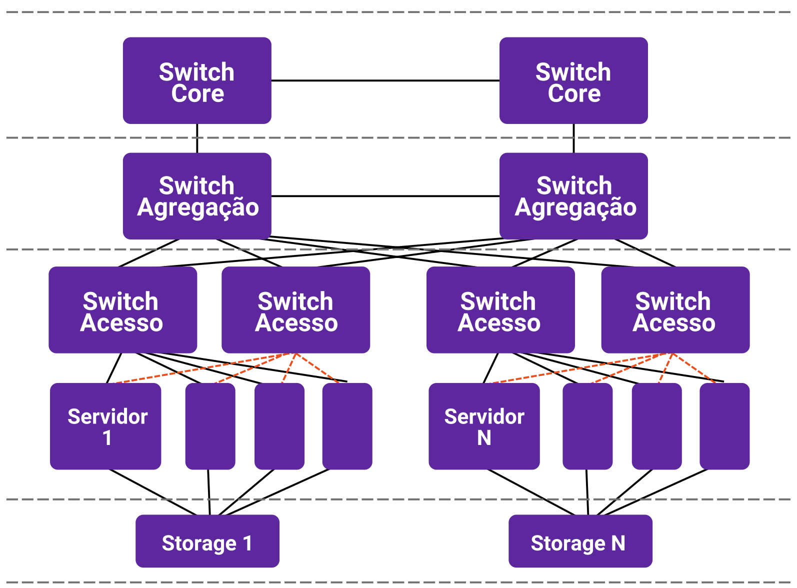
Annex IV • Network Architectures

Tier Network Architecture

The traditional 3-tier network architecture is well suited for traffic between servers connected to the same access switch and from servers to external destinations. However, it is not suitable for large virtualized HPC data centers where computing and storage servers can be located anywhere in the data center.

In this network architecture, there is a need for data to perform six separate hops to traverse the switching layers to reach the destination server.

All cabling for the traditional 3-tier network architecture follows the hierarchical star cabling topology specified in the ANSI/TIA-942 standard.

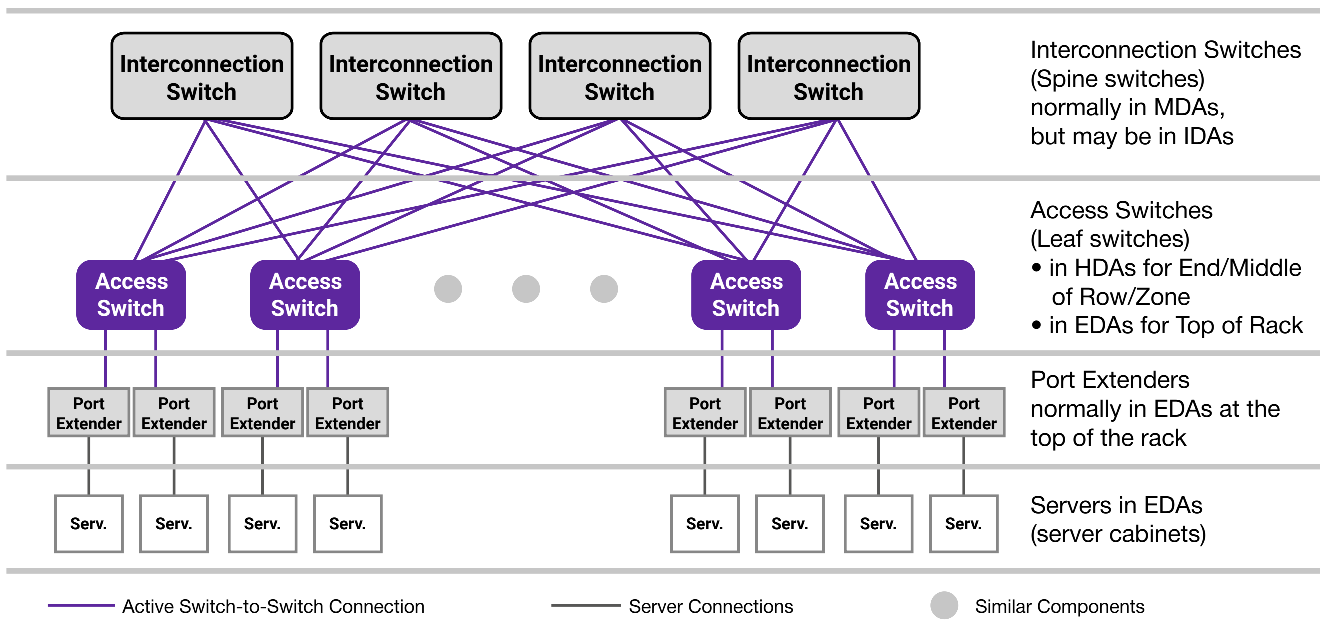


2-Tier Network Architecture (Spine-Leaf)

2-tier or spine leaf network architectures are intended to provide low-latency, high-bandwidth communication between any two points in the switch network. This type of architecture typically uses only one or two layers of switches. These switches feature a large number of connections to other switches. And these connections are all active to provide multiple paths that minimize latency and to provide maximum bandwidth within the spine leaf network.

This type of network architecture can be implemented using the cabling topology specified in the ANSI/TIA-942 standard. Some variant and spine-derived leaf, mesh, or full mesh network architectures require backbone cabling between peer distributors, for example, between HDAs. Some require direct cabling between switches located in different EDAs (for example, between top-of-rack/cabinet switches). Computers and storage servers can be connected to multiple access switches for redundancy.

The inherent benefits of this type of flatter network architecture in the spine leaf configuration is to reduce the number of switching layers, which decreases the number of hops, as well as the associated latency, by up to 33%.



Annex V • Technical Manuals and Websites

When developing data center projects, the adoption of consolidated standards and guidelines is essential to ensure performance, security, standardization, and longevity of the infrastructure. Among the main technical references used worldwide, the contents made available by TIA FOTC (*Fiber Optics Technology Consortium*), BICSI (*Building Industry Consulting Service International*) and IEEE (*Institute of Electrical and Electronics Engineers*) stand out, all of which are widely recognized for their technical depth and adherence to the real needs of the market.

TIA FOTC – Fiber Optics Technology Consortium

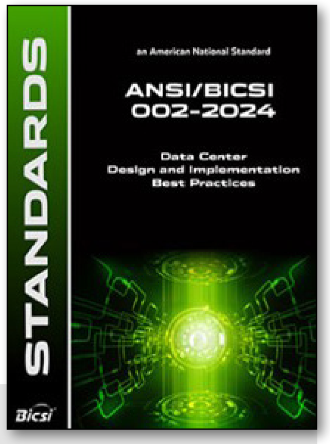
When developing data center projects, the adoption of consolidated standards and guidelines is essential to ensure performance, security, standardization, and longevity of the infrastructure. Among the main technical references used worldwide, the contents made available by TIA FOTC (Fiber Optics Technology Consortium), BICSI (Building Industry Consulting Service International) and IEEE (Institute of Electrical and Electronics Engineers) stand out, all of which are widely recognized for their technical depth and adherence to the real needs of the market.

In the context of data centers, the TIA FOTC material offers essential references on:

- ✓ good practices in the design and installation of optical cables;
- ✓ performance requirements and compatibility between components;
- ✓ recommended topologies for high-density environments;
- ✓ testing parameters, certification and optical inspection;
- ✓ technological trends in fiber, connectivity and transmission.

Because it is linked directly to the committees that develop TIA standards, FOTC is a reliable and continuously updated source. Its content helps designers align practical solutions with what is technically standardized, ensuring compliance with standards widely accepted in the North American market and adopted internationally.

BICSI



BICSI is one of the most respected organizations in the world when it comes to standards, technical manuals and professional training in telecommunications infrastructure and data centers. BICSI stands out for the production of comprehensive technical manuals, such as the BICSI 002 standard – Data Center Design and Implementation Best Practices, considered a global reference for data center planning and implementation.

In project development, BICSI's contributions include:

- ✓ complete guidelines for data center design, construction, and operation;
- ✓ recommendations for physical architecture, energy, air conditioning and security;
- ✓ specifications for optical and copper cabling;
- ✓ criteria for redundancy, availability and functional classification;
- ✓ practices consolidated by the experience of industry experts.

BICSI's approach is highly multidisciplinary: it integrates aspects of physical infrastructure, connectivity, energy efficiency and management, resulting in a holistic view of the environment. For designers, this provides a complete framework for technical and operational decisions that go beyond cabling standards.

BICSI – TDMM

The TDMM (Telecommunications Distribution Methods Manual) is BICSI's main technical manual and one of the most complete and internationally respected references for the design, installation and management of telecommunications infrastructures. Now in its 15th edition, TDMM draws on decades of industry practice, international standards, and expert input to provide a comprehensive guide that covers everything from fundamentals to advanced applications.

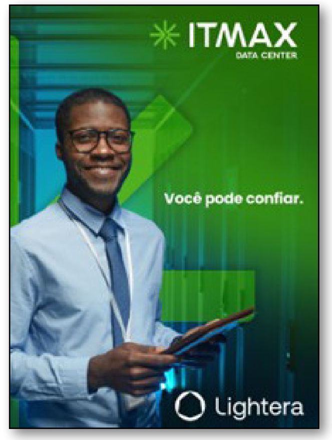
IEEE

The IEEE (Institute of Electrical and Electronics Engineers) is the body responsible for developing the IEEE 802.3 family Ethernet standards, which define all electrical, optical, mechanical, and functional specifications for Ethernet networks used globally. The IEEE institutional website, especially the section dedicated to IEEE 802, is an indispensable resource for designers and engineers who need to understand or specify Ethernet applications in data centers.

Among the main benefits of using IEEE references in project development are:

- ✓ Access to official Ethernet standards;
- ✓ Roadmaps and technological trends;
- ✓ Regulatory updates and working groups;
- ✓ Compatibility between Ethernet applications and cabling.

Lightera Guide – ITMAX – Data Center



In addition to the guidelines and references present in BICSI's content, there is also a guide prepared by Lightera containing various information regarding the Data Center and market news, from the scope of business to key concepts of structured cabling and optical network components.

This guide has the function of clarifying concepts considered complex in a material whose understanding is made in a simpler way. To do this, it makes use of images and drawings with a focus on the reader's understanding, in addition to, along with this, showing the Lightera solutions available for your business.

Annex VI • Main types of data centers

The data center is an ecosystem made up of interdependent parts and components. And as such, it demands the existence of a sensitive balance between all parts and components, ensuring that they interoperate with each other in a harmonious way. Not only do the parts and components need to work properly together, but all aspects of the data center must also address the goals of computing and implementing sustainable facilities.

Within this ecosystem, the "quadrinity" of the elements: electricity, air conditioning, computing and communication networks, act in an interdependent way, becoming the basis for all the dimensioning of the operating subsystems, in addition to the civil and structural part of the data center. For example, the fluctuations that occur during the processing of workloads interfere with energy consumption and the air conditioning elements together with the communication networks must adapt their parameters to these fluctuations. These four intertwined elements are the core for the design, implementation, and operation of HPC data centers comprehensively.

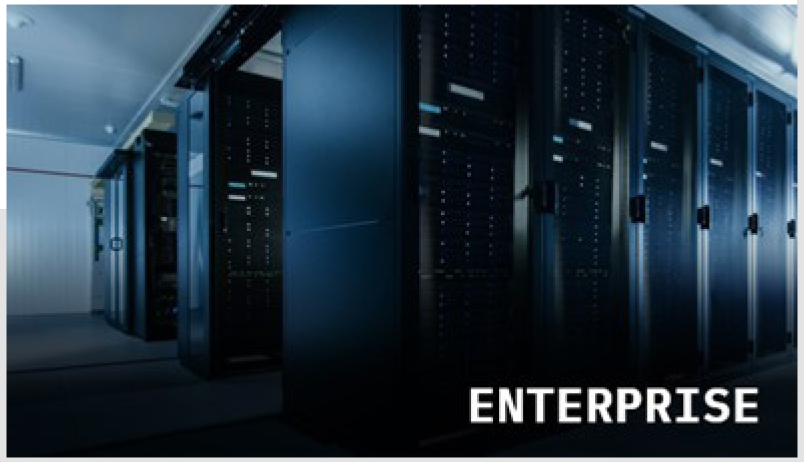
AI workloads are classified into two broad categories—AI training and AI inference—based on the tasks they perform. The AI training process creates the initial AI model. It includes data collection, selection, training, evaluation, deployment, and model monitoring, which involves intensive use of GPUs. After the model is developed, the inference process can be started. Inference is tied to permissions to end users or things so they can interact with the model.

The network plays a critical role in ensuring the best possible performance for training and inference tasks. It is essential to implement well-designed back-end and front-end network architectures that can meet the stringent requirements of AI workloads, which include high reliability, speeds, capacities, low latency, and low-loss networking. These networks must be able to maximize the utilization of computing resources to achieve the shortest possible work completion times for these workloads.

And to meet this new technology scenario, new requirements for robust infrastructures for HPC and AI data centers are necessary and that strongly impact the processes from the design of their projects to their entry into operation.

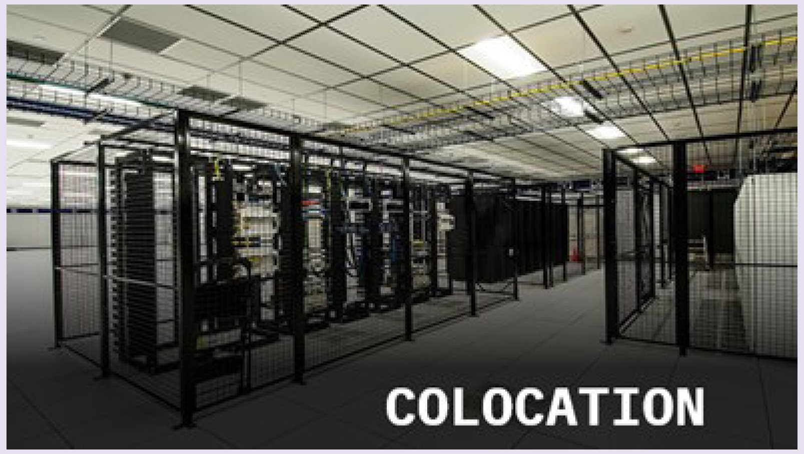
Data Centers Enterprise

An Enterprise Data Center, or Corporate, is the most widespread type of data center on the market. This model can be within the organization's own environment, having its own Information Technology (IT) infrastructure and a properly controlled space. This type of DC is designed to meet internal demands, such as corporate systems, databases, and business applications. It has high control over security, network settings, access and maintenance policies. However, it involves high costs of physical infrastructure, energy, cooling, technical staff and periodic technological updates. It may be suitable for businesses that want complete autonomy in managing their IT resources.



Data Centers Colocation

In this model, the client company allocates its servers and equipment in a third-party data center. That is, the hardware is owned, but the location, power, cooling, security and connectivity are provided by the operator. There are possibilities to hire from a position within a rack for a single server to entire rooms with hundreds of racks and servers. A modality similar to the colocation DC is the hosting DC, which offers, in addition to the physical space and support systems, the servers and applications themselves, as well as technical support for operation and maintenance.



Data Centers HPC

An HPC (High Performance Computing) data center is designed to process large volumes of data at very high speed, using clusters of servers that work in parallel to form supercomputers. Used in areas such as medical scientific research, climate modeling, 3D simulations, geophysical analysis, aerospace, finance, and pharmaceutical development. Efficiency depends on specialized hardware, low-latency networks, and advanced cooling systems, due to high power consumption. These environments support complex loads that require massive performance, above what typical enterprise environments offer. The main objective is to maximize processing capacity to solve complex tasks in a reduced time.

Data Centers of AI

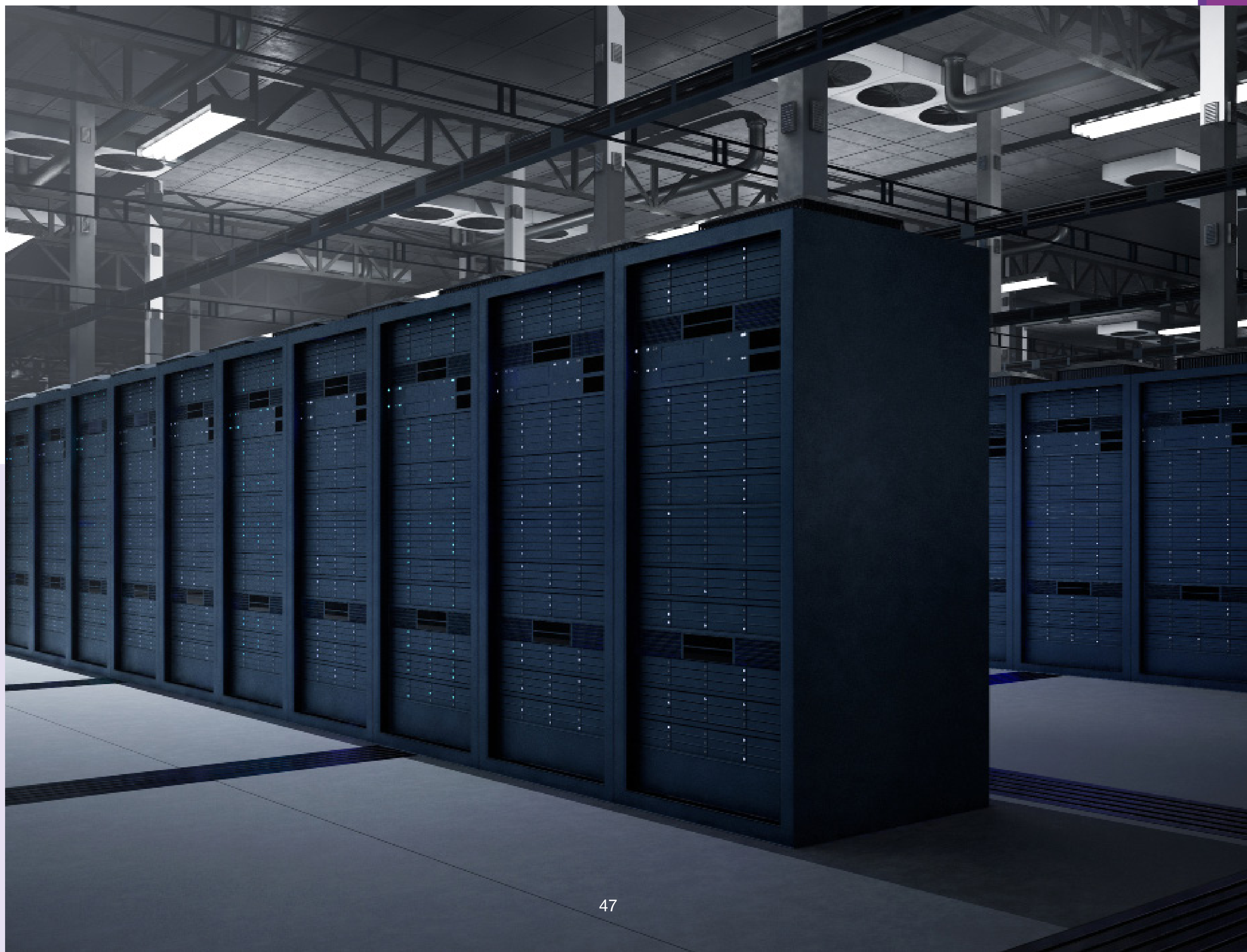
The AI data center is optimized to train and run artificial intelligence models, such as deep neural networks. Unlike traditional data centers, which primarily utilize CPUs for general tasks, AI data centers are designed around specialized hardware, such as thousands of GPUs (Graphics Processing Units) and TPUs (Tensor Processing Units), which are essential for the accelerated computing required for AI. In addition, it needs high-speed storage and management system to handle large data sets. These data centers require high power density and advanced cooling, often using techniques such as liquid cooling and immersion cooling.

Annex VII • Concept of PODs

A Performance Optimized Data Center (POD) is a modular unit of infrastructure that bundles a replicable set of racks, switch network, structured cabling, power, and cooling. It functions as a “building block” of the data center: instead of designing the entire facility as a single large space, the data center is organized into independent modules, which can be replicated as demand increases. It allows you to standardize the layout and infrastructure, reducing complexity and facilitating future expansion. Each POD is treated as an operable cell: teams know how to install, operate, and maintain because they all follow the same architecture.

As examples of application, the following can be highlighted:

- ✓ In a workload expansion, you can choose to install a completely new POD, reducing deployment time and keeping the current environment stable;
- ✓ In an AI workload scenario (which often requires GPU servers with high power consumption and high heat dissipation), demand may be concentrated on a liquid-cooled POD;
- ✓ In a replacement of “old” areas within a data center, there is the possibility of creating a POD with scalable topologies and architectures and migrating services gradually without paralyzing the environment.



Annex VIII • Megatrends

AI applications operate on the same physical processes involved in all forms of computing: manipulating the flow of electrical energy in a circuit to perform operations. But training today's AI language models requires computing performance at unprecedented magnitudes that can reach hundreds of millions of quadrillion training operations. The extended computing demands of AI applications present unique challenges for HPC data centers.

Ethernet, InfiniBand, or both?

The Ethernet standard is in the "de facto" lead for most networking needs with its broad support for TCP/IP requirements, simplicity of use, security, scalability, and management, making it ideal for front-end AI networks, including connections between switches, storage fabrics, and management networks.
The InfiniBand standard has been featured in HPC data center networks, established as a viable alternative to back-end GPU interconnections in AI clusters due to its Remote Direct Memory Access (RDMA) technology that can handle multiple high-bandwidth, low-latency parallel connections for data transfer.
Both the Ethernet standard and the InfiniBand standard will coexist in back-end AI clusters, and front-end AI networks will continue to employ the Ethernet standard. Both standards have very positive characteristics for implementation with AI network architectures, being able to support speeds of 800 Gb/s and 1.6 Tb/s.

Must-have: ULL Connectivity

For Ethernet and InfiniBand deployments using optical structured cabling in back-end and front-end AI networks, it is imperative to use ultra-low loss (ULL) MPO/MTP connectivity that meets stringent channel insertion loss requirements based on fiber types, distances, and applications, as shown in the following example for an application 800G.

Connector type: MPO/MTP
Transceiver module: QSFP-DD, OSFP
Published as **IEEE Std 802.3df™:** Media Access Control Parameters for 800 Gb/s and Physical Layers and Management Parameters for 400 Gb/s and 800 Gb/s Operation in 2024.

800GBASE-SR8				
Parameter	**OM3**	**OM4**	**OM5**	**Unit**
Operating wavelenght	850			
Modal bandwidth (min)	2.000	4.700		MHz-km
Operating range	0.5 to 60	0.5 to 100		m
Insertion loss (max)	1.7	1.8		dB
Cabling skew (max)	79			ns
Cabling skew variation	2.4			ns

Source: TIAFOTC – www.tiafotc.org

APC polishing on MPO/MTP connectors with multimode fibers

High-speed 400 Gb/s and 800 Gb/s applications in addition to future 1.6 Tb/s applications are more susceptible to optical reflectance [dB], due to a higher signal-to-noise ratio (SNR), coupled with the stringent regulatory requirements for insertion loss [dB] specified for the transmission channel. Lower reflectance performances can negatively influence channel insertion loss, reducing transmission performance. For these reasons, manufacturers are testing the use of APC polishing for MPO connectors with multimode fibers, in addition to traditional single-mode MPO connectors for high-speed AI connections.

Ultra-High Density (UHD) Fiber Optic Cables

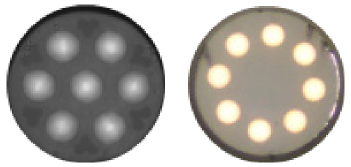
As described earlier, AI applications operate in the same physical processes as a network and for large-scale AI training and inference require some factors from the projects to be considered:

- ✓ **Parallel computing capacity;**
- ✓ **Network scalability;**
- ✓ **Complexity of implementation.**

These points refer to the high availability of optical fiber, which results in the use of *Rollable Ribbon* cables with up to 6,912 fibers, the well-known ultra-high-density cables of the acronym *UHD-Ultra High Density.*

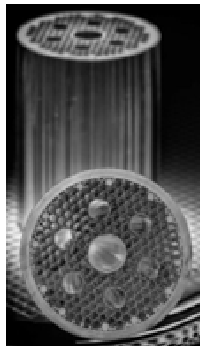
Multicore Fibers (MCF)

- ✓ **Multiple cores per fiber**
- ✓ **Alta densidade, menor consumo por bit**
- ✓ **Ideal for submarine routes and continental networks**
- ✓ **Technology in advanced stages of applied research – ready for the next generation of global optical networks.**



Hollow Core

Hollow-core fiber to create a low-latency link between a commercial data center and its customer, demonstrating the ability to protect data using quantum cryptography.



Annex IX • Lightera Training Courses

In addition to the standards, manuals and good practices available on the internet and, in part, here in this guide, Lightera also provides specialized training on its own platform, with modules aimed at developing skills in data centers.
These training courses complement the study of standards and offer a practical, expert-led approach, facilitating the application of concepts in real projects. Below are the links to access these training courses:

Data Center training

Annex X • Lightera Extended Warranty

Finally, Lightera offers the best connectivity solutions for your needs and **certifies its operation for up to 25 years**.

The 25-year extended warranty reinforces the company's commitment to the reliability and durability of its optical and data center infrastructure solutions. This warranty covers not only any manufacturing defects but also ensures the performance of the system for decades, as long as it is designed and installed according to the technical specifications and recommended best practices.

By opting for certified solutions with extended warranty, the customer obtains **operational security, performance predictability and maintenance cost reduction,** ensuring that the environment remains in compliance with international standards for transmission and optical integrity.

Learn more: