APPLICATION GUIDE

STRUCTURED CABLING FOR DATA CENTER ENVIRONMENTS

FURUKAWA

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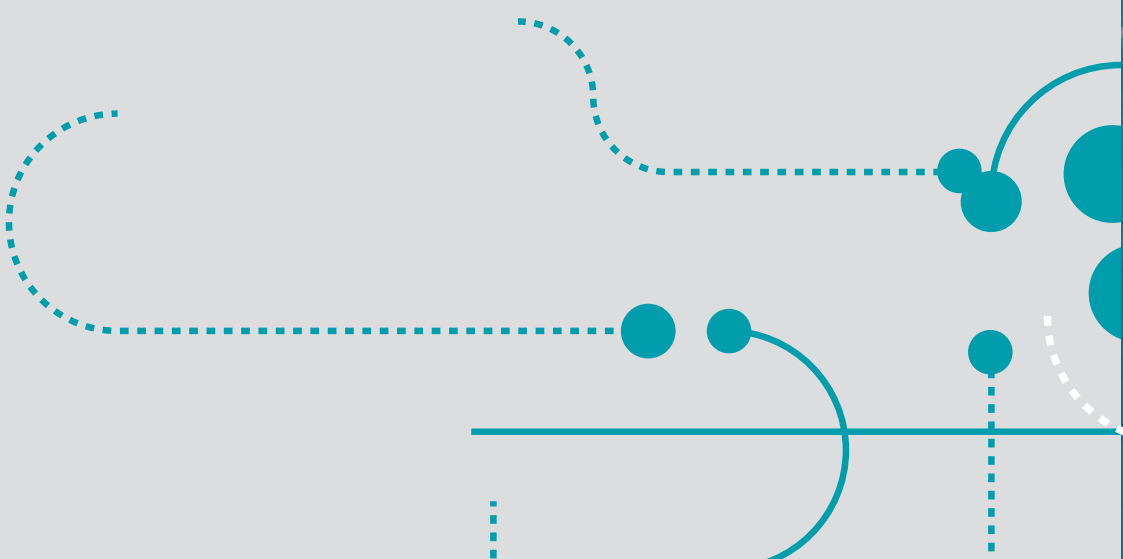

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CONCEPTS AND TYPES OF DATA CENTER

THE CENTRAL ELEMENT OF **IT** INFRASTRUCTURE FOR ANY ORGANIZATION IS THE **DATA CENTER**; AND EVERY ORGANIZATION HAS ONE TYPE OF **DATA CENTER** – IT IS THE INTEGRATED SET OF HIGH TECHNOLOGY AND HIGH RELIABILITY COMPONENTS, WHICH ENABLES PROVIDING INFRASTRUCTURE SERVICES WITH AGGREGATED VALUE, PERFORMING DATA PROCESSING AND STORAGE IN LARGE SCALE AND WITH HIGH AVAILABILITY.

Categories

Data Centers can be classified according to property versus services they are designated to:

- **Enterprise (private domain)**: this kind is the most common and the biggest part of the existing Data Centers; is operated by private corporations, institutions or governmental agencies, with the main purpose to store data resulting from internal processing operations and process data from applications aimed to the internet.
- **Internet (public domain)**: this kind belongs to and is operated by a telecommunication service provider, telecom carriers or other service providers, whose main means of communications is the Internet.
- **Co-location**: contracting of the physical space of the racks and the power and telecommunication infrastructure; however, the servers, the applications, the management, the monitoring and the support belong to the contracting party.
- **Hosting**: a line of services offered to upgrade hardware and software investments, in addition to the physical infrastructure of racks, power and telecom – the servers, the storage and the backup unit, as well as professionals and support services.

1.1 PROTOCOLS

Large Data Centers can be extremely complicated, with multiple protocols, setup data and different technologies used.

Many are communication protocols among the electronic equipment in a Data Center. Currently, in general, the dominating protocols are Ethernet for Local Area Network (LAN) and Fibre Channel for Storage Area Network (SAN).

Fibre Channel	Storage	**Unified Fabric Ethernet**
Infiniband	Cluster (HPC)	
Ethernet	Servers / Blades / DCIM / Automation / SDN / NaaS	

There are groups supporting the use of the Ethernet standard for all types of interconnection in the Data Center. Converged Enhanced Ethernet (CEE), which has a working group in IEEE 802.1 Data Center Bridging, which describes an expanded Ethernet allowing convergence of LAN, SAN and interconnection for high performance applications that demand low latency for a single fabric Ethernet. The cost of the Unified Fabric Ethernet is low and there will be new advanced speed (10/40/100 Gbps). It is believed that the iSCSI and FCoE protocols will be highlights in high-speed networks.

Ethernet

The Ethernet applications, according to IEEE 802.3, are dominating the networking area in the current Data Centers. In the access areas, it is common to use 1 Gigabit Ethernet and 10 Gigabit Ethernet. In the aggregation and core areas, 10 Gigabit Ethernet through optical fiber cables is the cabling designers´ choice worldwide. In mid-2010, IEEE 802.3 also defined 40/100 Gigabit Ethernet.

40GbE Roadmap

Type of Interface	Electric Interface with the Optic Module	Distance	Type of Media	Date of Publication
40GBASE-CR4	Not applicable	7 m	Twinax	2010
40GBASE-SR4	XLAUI/XLPPI	100/150 m	OM3/OM4	2010
40GBASE-LR4	XLAUI/XLPPI	10 km	OS1/OS2	2010
40GBASE-FR	XLAUI	2 km	OS1/OS2	2011
40GBASE-ER4	XLAUI	40 km	OS1/OS2	2015 (estimated)
40GBASE-T	Not applicable	30 m	CAT 8	2016 (estimated)

Source: http://www.ethernetalliance.org/subcommittees/roadmap-subcommittee/

100GbE Roadmap

Type of Interface	Electric Interface with the Optic Module	Distance	Type of Media	Date of Publication
100GBASE-CR10	Not applicable	7 m	Twinax	2010
100GBASE-SR10	CAUI-10	100/150 m	OM3/OM4	2010
100GBASE-LR4	CAUI-10	10 km	OS1/OS2	2010
100GBASE-ER4	CAUI-10	40 km	OS1/OS2	2010
100GBASE-CR4	Not applicable	5 m	Twinax	2014
100GBASE-SR4	CAUI-4	70/100 m	OM3/OM4	2015
100GBASE-LR4	CAUI-4	10 km	OS1/OS2	2015 (estimated)

Source: http://www.ethernetalliance.org/subcommittees/roadmap-subcommittee/

FCoE Standard (Fibre Channel over Ethernet)

The FCoE standard, developed by T11, defines the FC frame mapping over Ethernet and enables converging the Fibre Channel traffic to a 10 Gigabit Ethernet network.

The table below, supplied by Fibre Channel Industry Association (FCIA), shows a roadmap of the speeds adopted by FCoE:

SPEED ROADMAP FOR FIBRE CHANNEL				
Type of Interface	**Transfer Rate (Mbps)**	**Equivalent Speed (GbaUD)**	**Date of Publication (year)**	**Availability on the Market (year)**
10GFCoE	2400	10.3125	2008	2009
40GFCoE	9600	4x10.3125	2010	2013
100GFCoE	24000	10x10.3125	2010	Market Demand
100GFCoE	24000	4x25.78125	2015	Market Demand
400GFCoE	96000	TBD	TBD	Market Demand

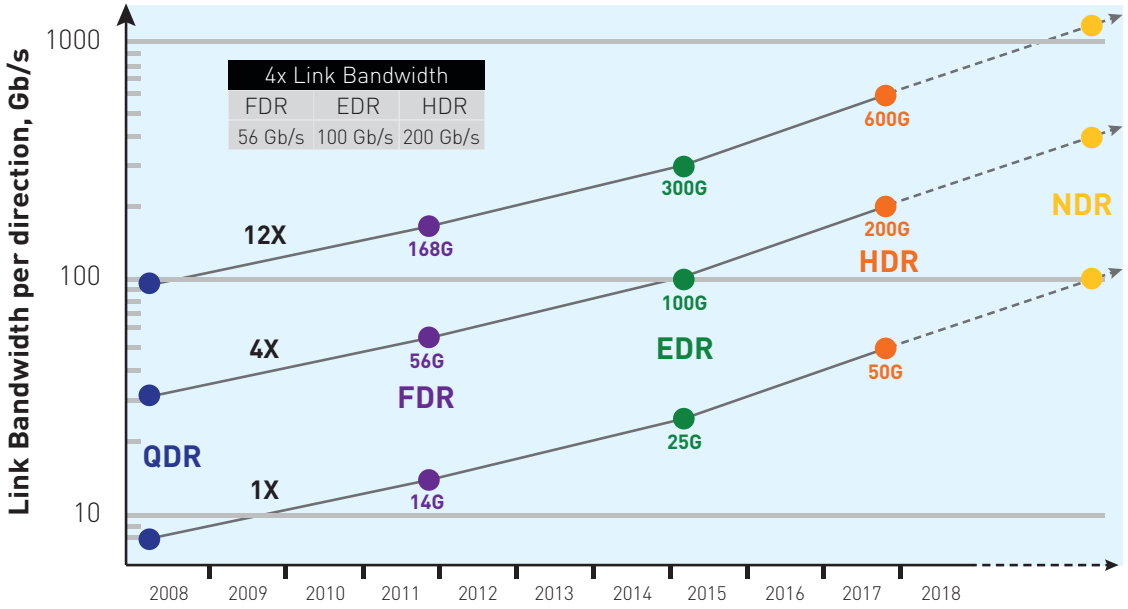
Source: http://fibrechannel.org/fibre-channel-roadmaps.html

For 10G FCoE, duplex serial transmission by optic fiber is used. The speeds of 40 and 100G FCoE will require parallel optic transmission. The Data Centers may install 12 fiber backbone cables with MPO connectors in OM3 or OM4 – currently available and which can be used either for cabling, which fulfills 10G FCoE, or to supply infrastructure for efficient migration in future parallel transmission.

FCIA adopted specific guideline in relation to cabling. The optic connectivity shall be in compliance with IEEE 802.3ae (10GBASE-SR) using optic fibers OM3 or OM4. In addition, for new installation, distances shorter than or equal to 100 m are recommended to be compatible with 40/100G Ethernet and 16 / 32G Fibre Channel.

Infiniband

Abbreviated as IB, Infiniband is a type of communication network used for connection between high performance computers, storages, on-board systems and mainly super-computers. The main characteristics are high speed rates and low latency. Its architecture allows "switch fabric" use or point-to-point connection, achieving speed up to 300 Gb/s, according to the roadmap foreseen in 2015.



Legend:

QDR – Quad Data Rate
FDR – Fourteen Data Rate
EDR – Enhanced Data Rate
HDR – High Data Rate
NDR – Next Data Rate

1.2 OPTIC FIBER X COPPER

A well-planned cabling system will serve current and future applications, but there are many doubts regarding the type of cabling to be used in the Data Center. Generally, the use of copper in internal installations still prevails, but fiber has been gaining space increasingly fast and in long terms, it presents lower Total Cost of Ownership (TCO) with simplification of the upgrade from the 1 Gbps and 10 Gbps standards to the 40 Gbps and 100 Gbps standards.

Currently, in Data Center environments, the copper-fiber ratio is 50:50, confirming this trend (BSRIA 2013).

1.3 OPTIC FIBER PERFORMANCE

The optical fiber connection can be multimode (MM) or single-mode (SM). The multimode optical fibers – OM – have up to 2 km reach (Ethernet 100BASE-FX) and lower cost, because they use LED or low-cost laser (VCSEL). The single-mode fiber – OS – reach up to 40 km; however, as they use laser, their cost is comparatively higher.

The media recognized by the TIA-942-A standard for optical cabling are: single-mode fiber (SM) and multimode (MM) (OM3 or OM4), where OM4 is recommended.

Ethernet: Distances (m) / Channel Attenuation (dB)										
ISO 11801	Core Diameter (microns)	Wave-length (nm)	Maximum Length (m) / Channel Attenuation (dB)				Ethernet Speed/ Optical Interface			
			1 Gb/s	10 Gb/s	40 Gb/s	100 Gb/s	1 Gb/s	10 Gb/s	40 Gb/s	100 Gb/s
OM1	62,5	850	275 / 2.6	33 / 2.4	-	-	1000BASE-SX	10GBASE-S	-	-
		1300	550 / 2.3	300 / 2.4	-	-	1000BASE-LX	10GBASE-LX4	-	-
OM2	50	850	550 / 3.6	82 / 2.3	-	-	1000BASE-SX	10GBASE-S	-	-
		1300	550 / 2.3	300 / 2.0	-	-	1000BASE-LX	10GBASE-LX4	-	-
OM3	50	850	-	300 / 2.6	100 / 1.9	100 / 1.9	-	10GBASE-S	40GBASE-SR4	100GBASE-SR10
		1300	550 / 2.3	300 / 2.0	-	-	1000BASE-LX	10GBASE-LX4	-	-
OM4	50	850	-	400 / 2.9	150 / 1.5	150 / 1.5	-	10GBASE-S	40GBASE-SR4	100GBASE-SR10
		1300	550 / 2.3	300 / 2.0	-	-	1000BASE-LX	10GBASE-LX4	-	-
OS1	8-9	1310	5.000 / 4.5	10.000 / 6.2	10.000 / 6.7	10.000 / 6.3	1000BASE-LX	10GBASE-L	40GBASE-LR4	100GBASE-LR4
		1550	-	40.000 / 11.0	-	-	-	10GBASE-E	-	-

Fibre Channel (FC): Distances (m) / Channel Attenuation (dB)					
Fiber Type	1 GFC	2 GFC	4GFC	8 GFC	16 GFC
OM3	860 / 4.6	500 / 3.3	380 / 2.9	150 / 2.0	100 / 1.9
OM4	860 / 6.6	500 / 3.3	480 / 3.0	190 / 2.2	125 / 2.0

As the data rates and the physical size of the Data Centers are increasing, the need to create a scalable network – in bandwidth, length and transmission speed – becomes extremely important.

Infiniband (IB): Distances (m)

The maximum distance of the channel depends on the data rate, the number of parallel transmission and the type of connector.

Type of Fiber and Connector	SDR (2,5 Gb/s)			DDR (5,0 Gb/s)			QDR (10 Gb/s)
OM3	IB 1x-SX	IB 4x-SX	IB-8x-SX, IB-12x-SX	IB 1x-SX	IB 4x-SX	IB-8x-SX, IB-12x-SX	IB 1x-SX
	500	200	200	200	150	150	300
	LC Duplex	MPO 12F	MPO 24F	LC Duplex	MPO 12F	MPO 24F	LC Duplex

The specification document issued by IB does not detail the use of OM4 fiber. And there is no detailing for QDR SX and LX links.

1.4 COPPER PERFORMANCE

Normally, as the links have shorter lengths, up to a hundred meters, copper cables are still used.

Definition ISO	Definition TIA	Frequency	Status
Class D	Category 5e	100 MHz	Published
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	Under development
Class II	Category 8.2	1600 – 2000 MHz	

The media recognized by the TIA-942-A standard for the copper cabling are CAT.6 and CAT.6A, where CAT.6A is recommended.

Ethernet: Distances (m)				
	1 GbE	10 GbE	40 GbE	100 GbE
Category 6	100	37 (TSB-155)*	-	-
Category 6A	100	100	-	-

Fibre Channel (FC): Distances (m)					
	1 GFC	2 GFC	4GFC	8 GFC	16 GFC
Category 6	100	70	40	-	-
Category 6A	100	100	100	-	-

***Note**: TIA/EIA TSB-155 is a technical bulletin from TIA, Telecommunications Systems Bulletin (TSB), known as "Guidelines for the Assessment and Mitigation of Installed Category 6 Cabling to Support 10GBASE-T." The guidelines contain additional recommendations to further characterize existing category 6 cabling plant as specified in ANSI/TIA/EIA-568B.2-1 for supporting 10GBASE-T applications.

1.5 ADVANTAGES OF THE OPTICAL FIBER APPLICATION

The fiber has a big number of advantages for any application at any speed.

- Immune to radio frequency interference (RFI) – its signals cannot be corrupted by external interference.
- Immune to EMI from external sources – fiber does not produce electronic emissions.
- There is no Cross-talk in fiber systems.
- No concern with grounding – with so many models of dielectric optic cables available, connection to earth can be eliminated and the lighting effects drop drastically.
- Optical fiber is the safest media, almost impossible to have information deviated.

2 PHYSICAL INFRASTRUCTURE

WHEN A DATA CENTER IS DESIGNED, MANY FACTORS SHALL BE CONSIDERED. FOR THIS PURPOSE, REGULATORY BODIES CREATE SPECIFIC STANDARDS FOR THIS CRITICAL APPLICATION ENVIRONMENT.

ANSI/TIA-942.A:2013
Telecommunications Infrastructure Standard for Data Centers

ISO/IEC 24764:2010
Information Technology – Generic Cabling Systems for Data Centres

CENELEC EN 50173-5:2012
Information Technology – Generic Cabling Systems – Part 5: Data Centres

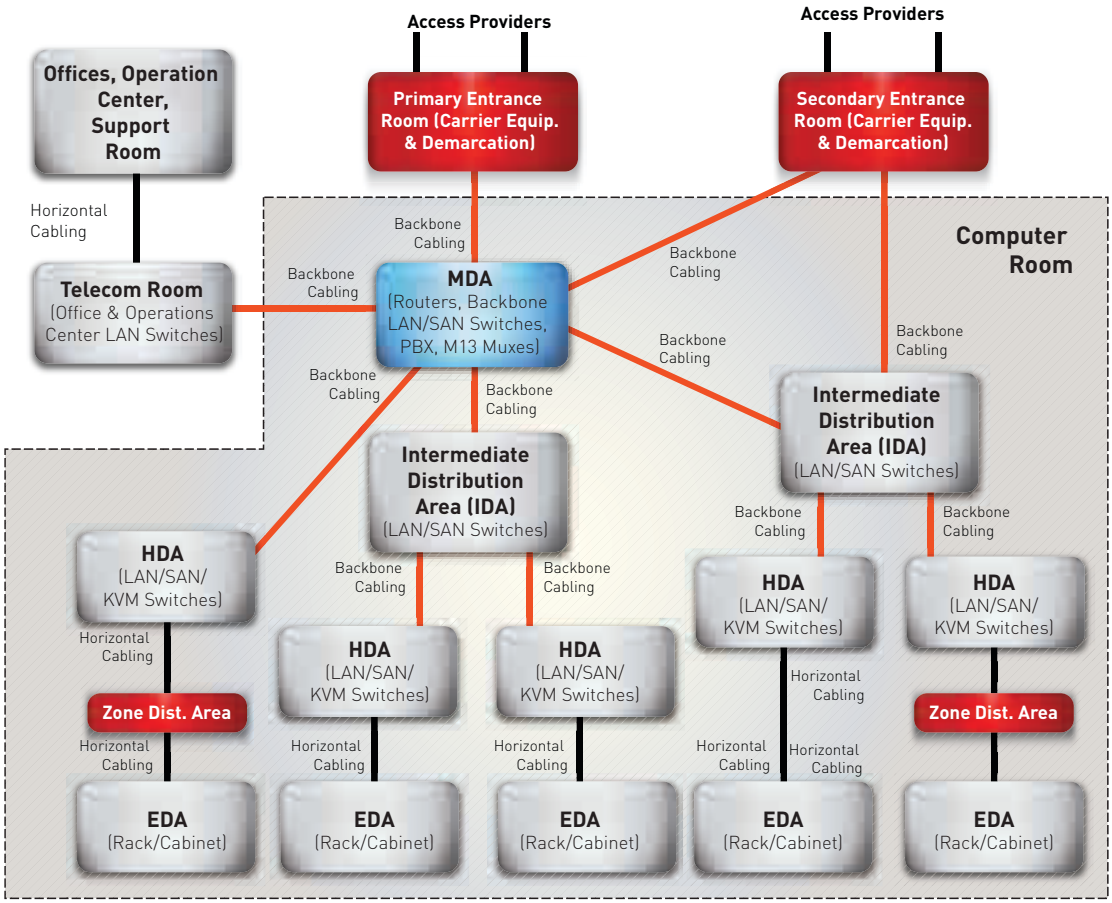
ANSI/BICSI-002:2014
Data Center Design and Implementation Best Practices

2.1 GENERAL CONCEPTS

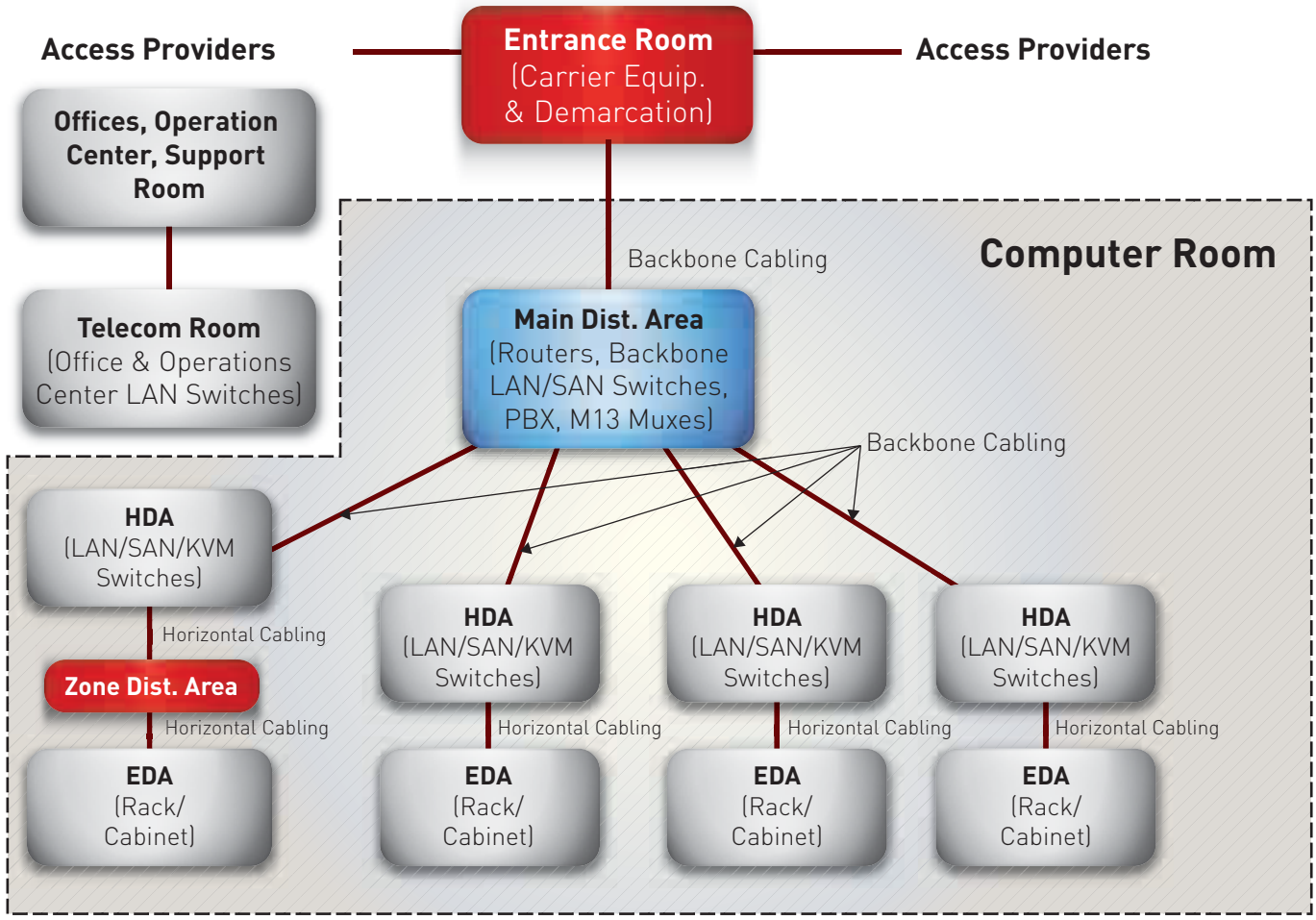
TIA-942-A suggests a topology, which can be applicable to any installation, regardless of the size – from small-sized to large scale Data Centers. Launched in 2005, this document defines the standards for telecommunication space, infrastructure components and requirements for each Data Center. In addition, it presents recommendations for topologies, distances and cabling, requirements for physical construction, identification, administration and redundancy.

The main elements of a Data Center, according to TIA-942-A, are:

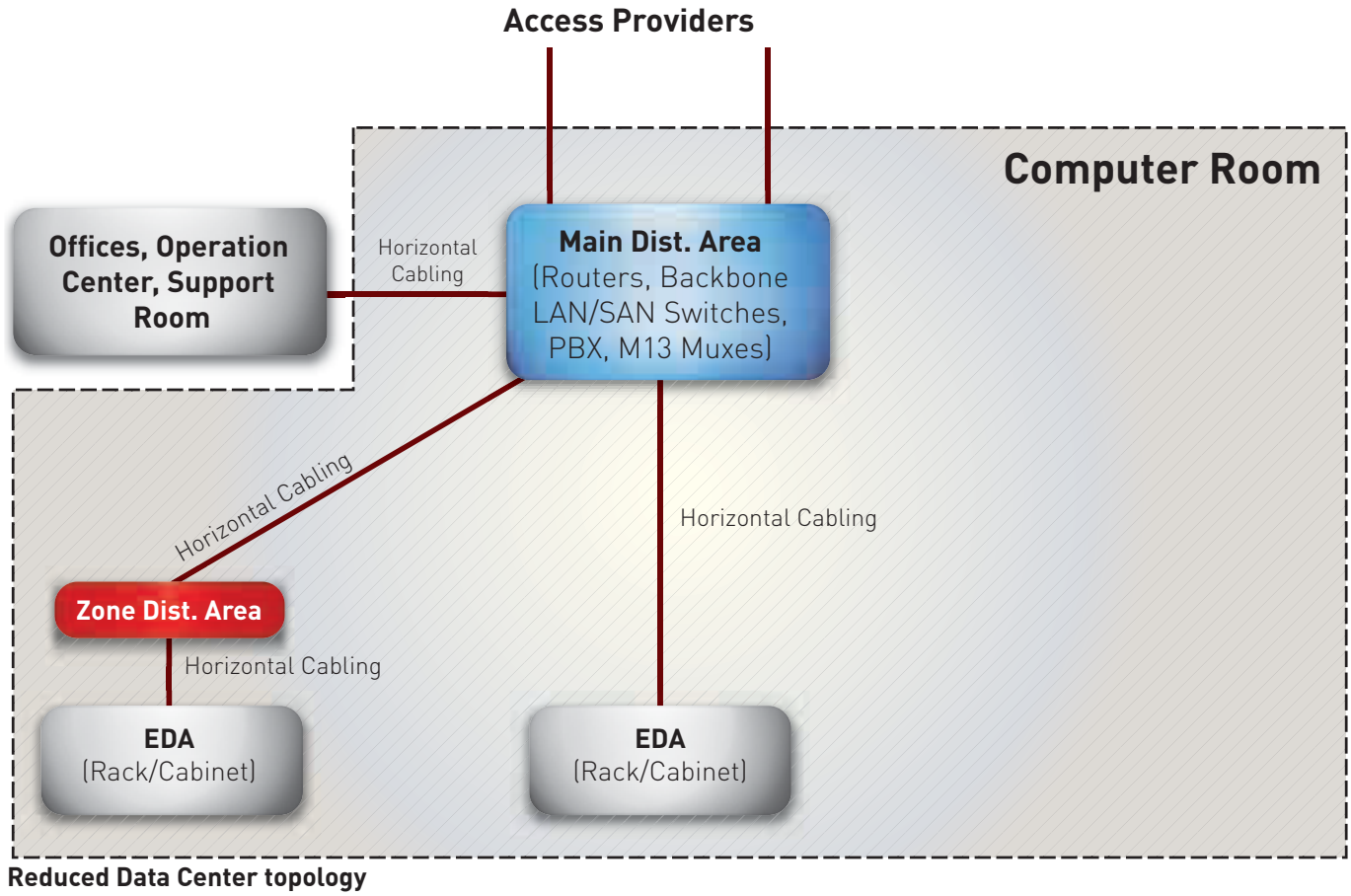
- **Entrance Room (ER)**: The entrance room is a space for interconnection between the structured cabling of the Data Center and the cabling coming from the telecommunication operators.
- **Main Distribution Area (MDA)**: It includes the main cross-connect, which is the main distribution point of a Data Center structured cabling. It is a critical area, where its main maneuvers are carried out.
- **Intermediate Distribution Area (IDA)**: Space designated to intermediary cross-connect, which is the secondary distribution structured cabling point of a second data-hall of a Data Center. It is a critical area as much as the MDA, where maneuvers are carried out in the data-hall, where it is installed.
- **Horizontal Distribution Area (HDA)**: This is an area used for connection with the equipment areas. It includes the horizontal cross-connect (HC) and intermediary equipment.
- **Zone Distribution Area (ZDA)**: Optional interconnection point of the horizontal cabling. Placed between HDA and EDA, it enables fast and frequent setup, generally positioned under the floor. It aggregates flexibility to the Data Center.
- **Equipment Distribution Area (EDA)**: Space designated to terminal equipment (Servers, Storage) and data or voice communication equipment (switches, switchboards).



Topology of a Data Center distributed with multiple ER



Basic Data Center topology

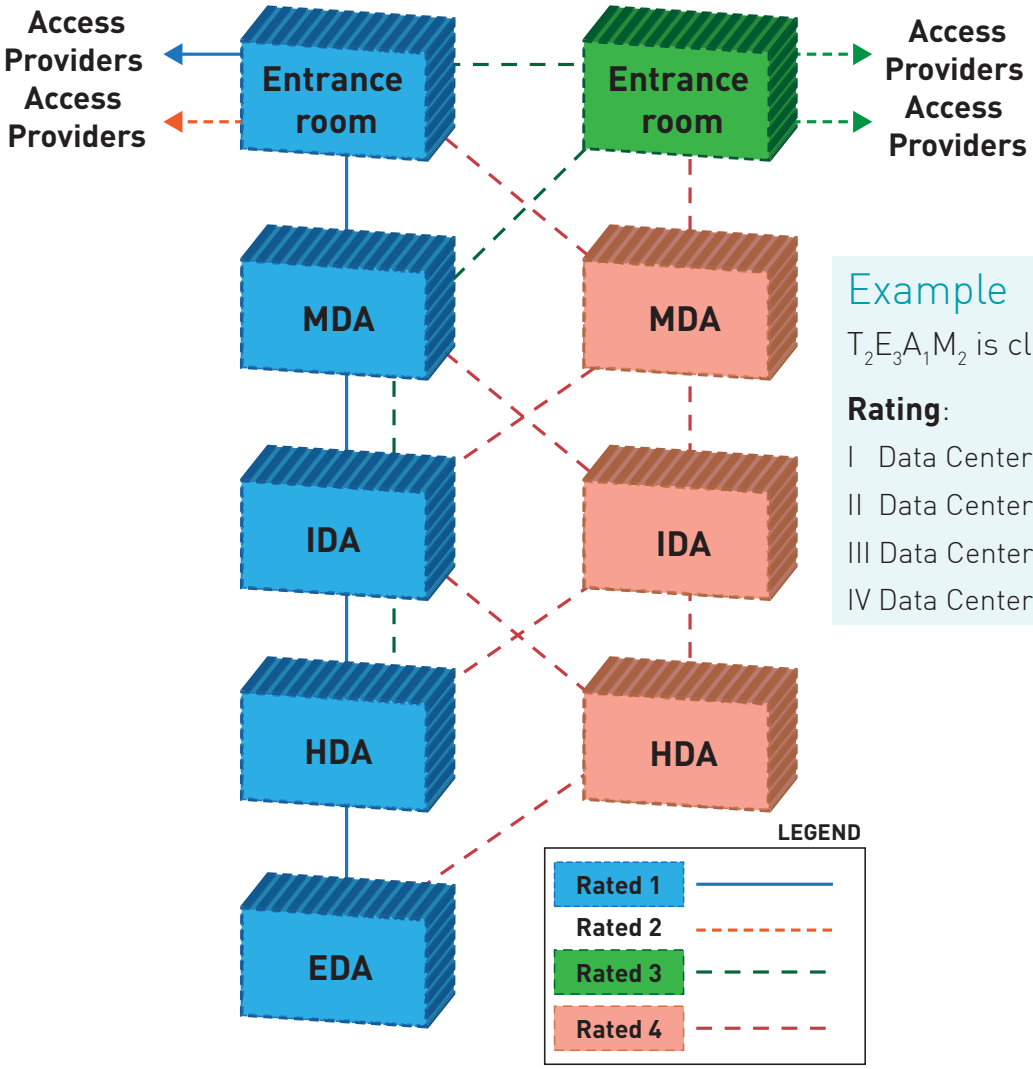


Reduced Data Center topology

2.2 REDUNDANCY REQUIREMENTS

According to the TIA-942-A standard, there is series of applicable rules to classify a Data Center. Called **ratings**, the classification considers 4 independent ranges for the Telecommunications, Electric, Architecture and Mechanical systems. These ranges are related to the availability of the Data Center, and can be different in each of the areas mentioned above.

Always the lowest range is considered for general classification.



Example

$T_2E_3A_1M_2$ is classified as: **Rated1**

Rating:

I Data Center: Basic

II Data Center: Redundant Capacity

III Data Center: Concurrently Maintainable

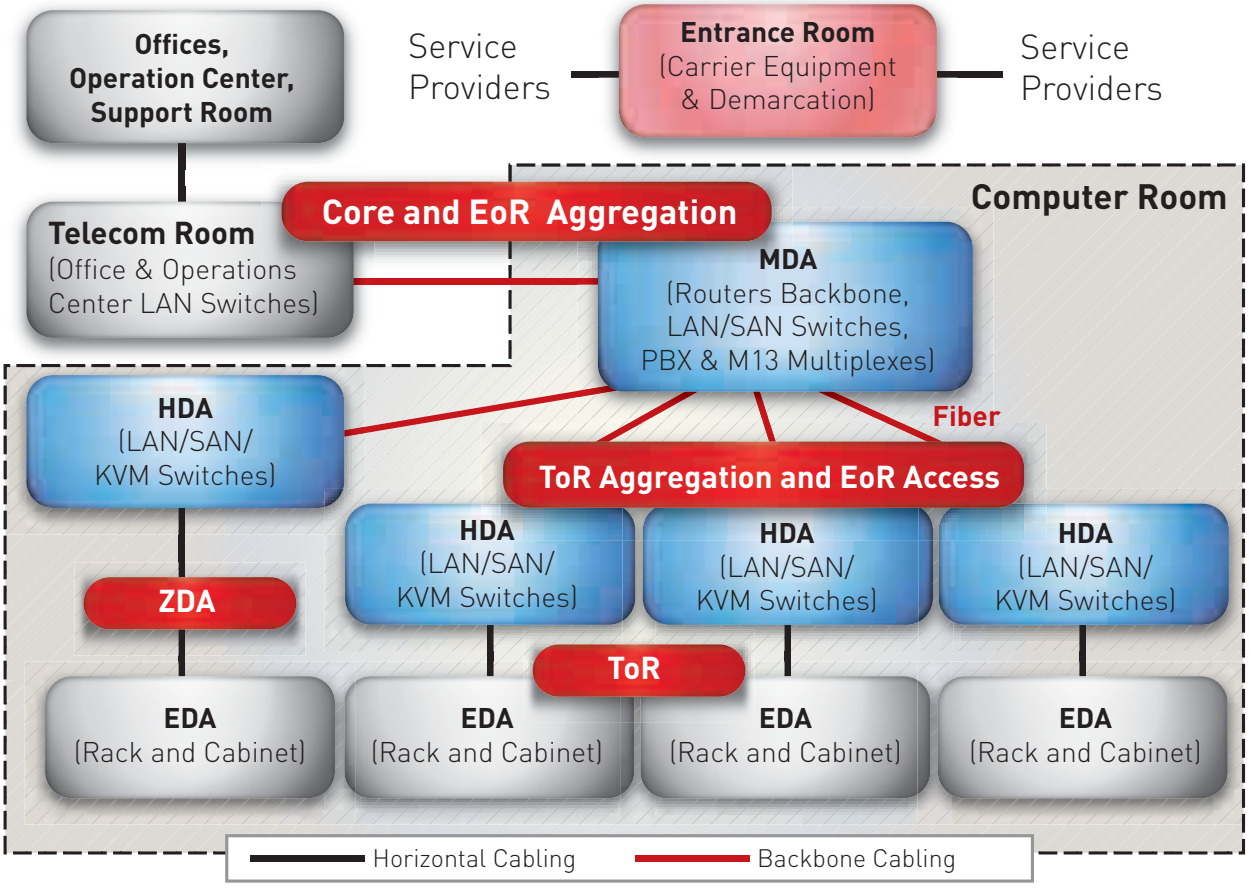
IV Data Center: Fault Tolerant

2.3 ARCHITECTURE

When built hierarchically, some more complex aspects in a Data Center are minimized, placing the whole structure in an easier to comprehend perspective. The hierarchy model built in networks composed of three layers (core, distribution and access) has equivalence in the Data Center:

- **Core** – responsible to transport big volume of traffic reliably and quickly. Any failure affects all network users.
- **Aggregation (distribution)** – it determines the fastest route to fulfill a requirement of a specific network service and delivers the route to the core layer.
- **Access (edge)** – it controls the access of the Data Center resources – servers and storage devices.

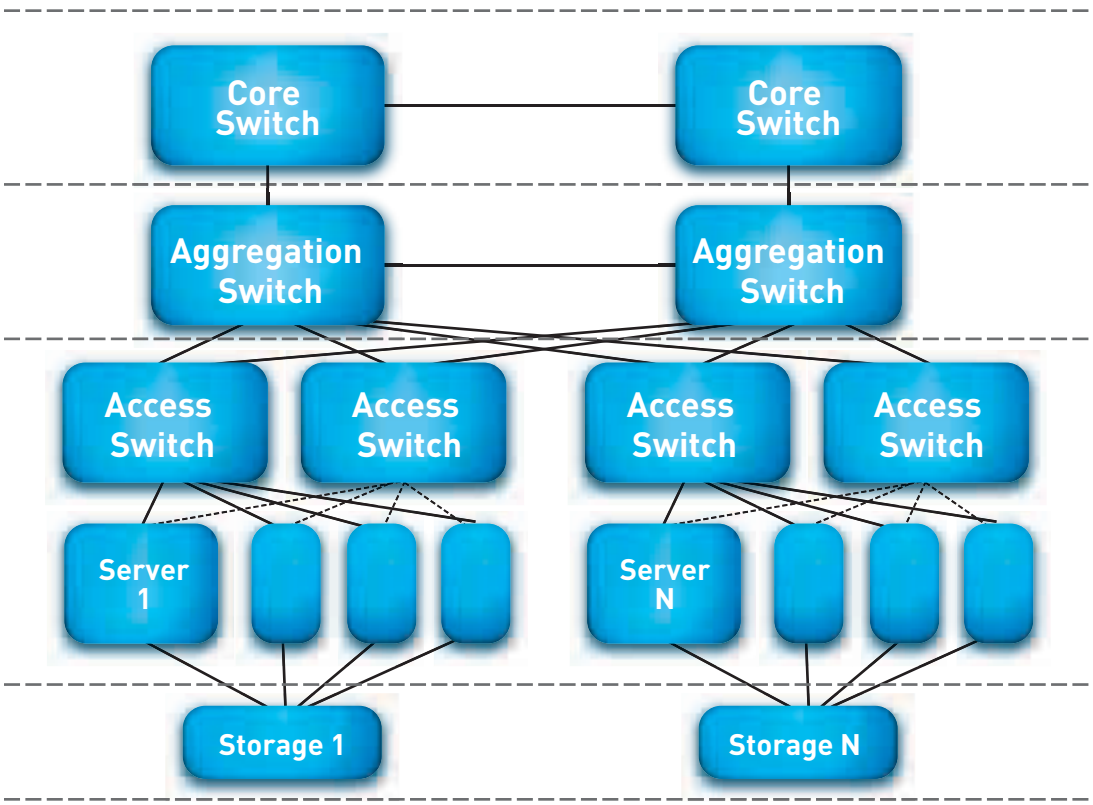
There is a direct relation between the topology proposed by TIA-942 and the hierarchy star topology:



The Data Center architecture is built in layers, because thus, performance, flexibility, scalability, resilience and management are obtained.

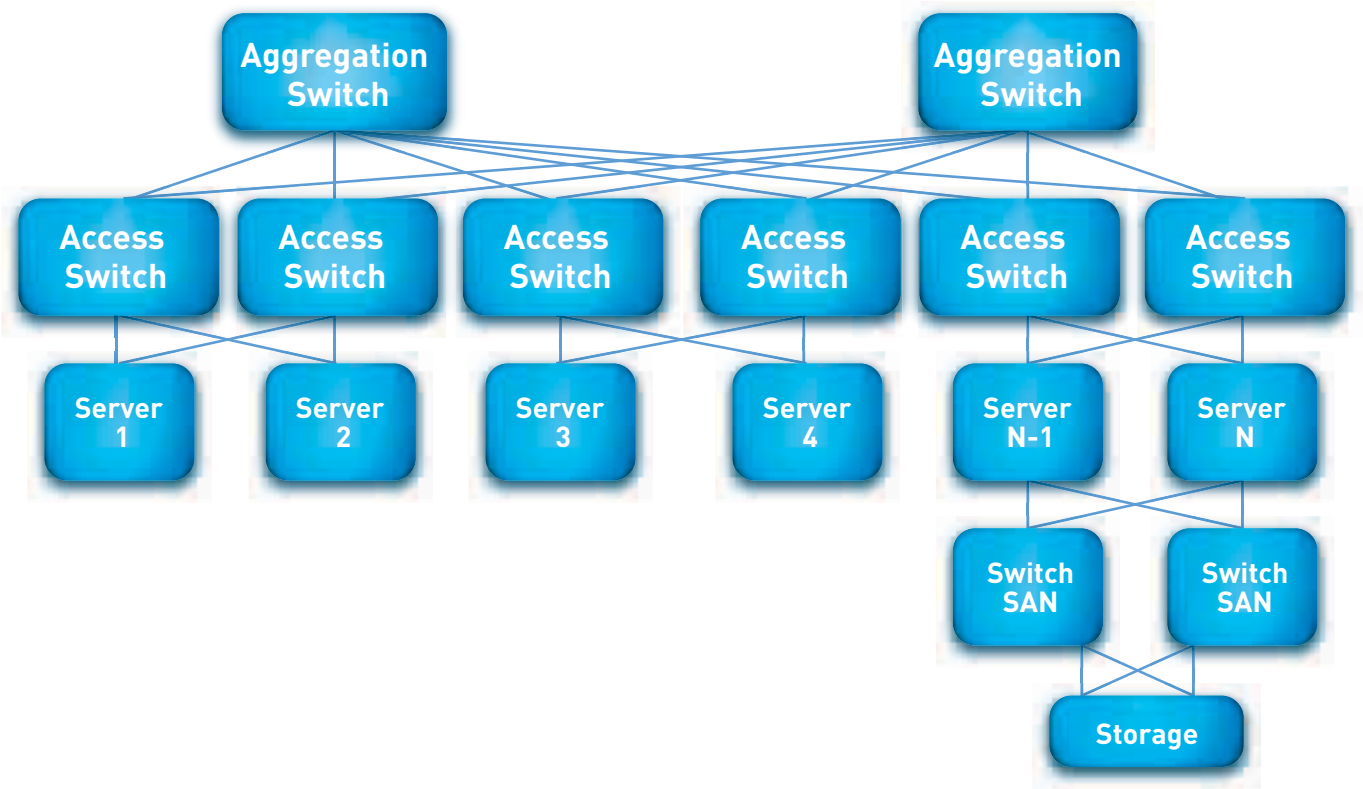
LAYER ARCHITECTURE

Used by 90% of the small and medium size Data Centers



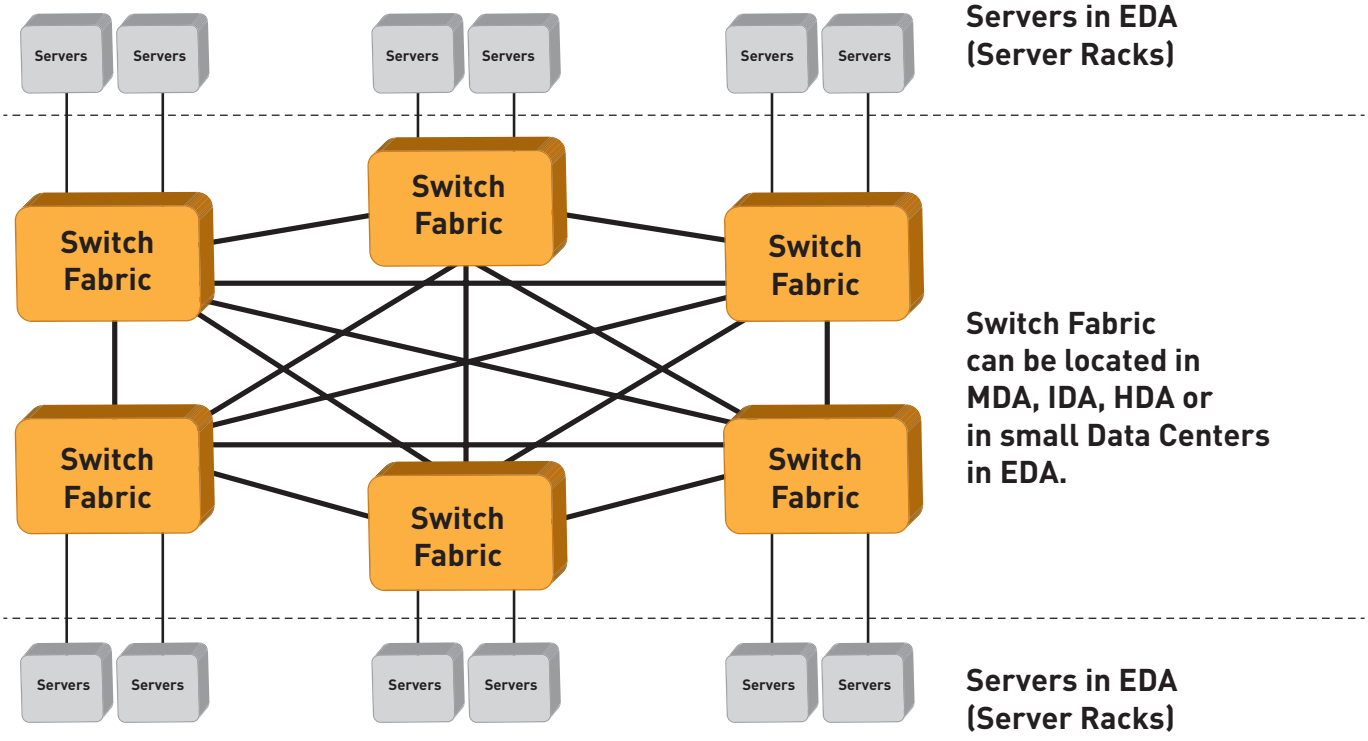
Collapsed Architecture

Used by most of the medium and large Data Centers



Switch Fabrics

Used to increase the performance of Data Centers with high-speed networks and high availability.



3 COMPONENTS

3.1 PRE-TERMINATED SYSTEM CONCEPT

The structured cabling systems, which use cables pre-terminated at the factory are recommended for plug-and-play applications, where simple installation is fundamental. Commonly used in optical channels, these systems enable the channel assembly with no need of splice between the components.

Main advantages:

- Flexibility and modularity, with physical space optimization;
- Scalability and facility of expanding with no quality degradation;
- Fast and easy installation and reconfiguration;
- Simple handling, no need of special tools;
- High performance at the connections.

Two optical components are essential in the pre-terminated systems for Data Center environments, where high speed and high density are required at the same time.

MPO Connector

MPO (Multi-Fiber Push On) connectors are multi-fiber connectors, which can hold from 04 to 72 optical fibers in a single connector.

The current applications contemplate 12-fiber connectors, and can achieve 24 fibers in a single connection. These are available in the male (with guiding pins) or female (without guiding pins) versions, and there shall always be a connection between one "male" element and one "female" element.

ATTENTION: The connection between two "female" connectors will not provide alignment of the fibers (the guiding pin is fundamental to assure their alignment) and the system will present loss of performance. The connection of two "male" MPO connectors, with the guiding pins on both sides, will cause damage to the connector structure.

Male MPO Connector (with guiding pin)

Female MPO Connector (without guiding pin)

NOTE: MTP© Connector is a type of MPO Connector. Both are fully compatible and can be used together in the high performance systems. The IEEE802.3ba standard related to the Ethernet transmissions in up to 100 Gbps, defines MPO Connectors as interface. Thus, this is the nomenclature used herein. Since MTP is a kind of MPO, it is contemplated in all items related to the MPO elements in this document.

MTP© is a USCONEC trademark

MPO Adapter

MPO adaptors are elements, which provide the alignment between two MPO connectors. Their polarity is according to the position of the connector slot key.

Adaptor with TYPE A polarity provides a key turned up and another one turned down. Both connectors are connected at 180° one towards the other. Black colored.

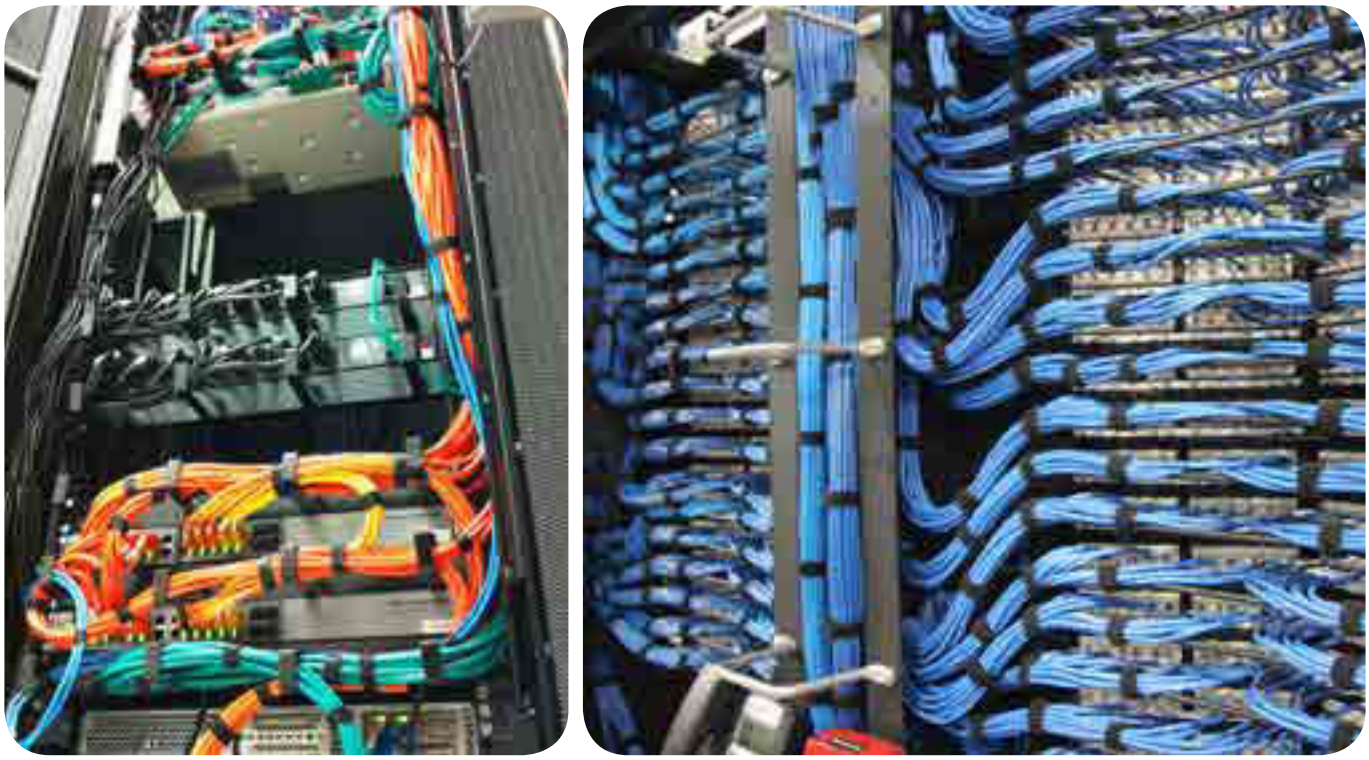
Adaptor with TYPE B polarity provides both keys at the same side. The connectors are connected at 0° one towards the other, both are at the same position. Gray colored.

3.2 STANDARD DENSITY X HIGH DENSITY

Each type of environment, according its size and its criticality, need solutions that fulfill all performance and density requirements. When we talk about large Data Centers, the points of big concentration are MDA, HDA and IDA – where the number of equipment units is extremely high.

In this direction, it is even more common using optical cabling, which already has physical space optimization advantages due to its design constitution.

Whithin its TeraLan optical product line, Furukawa provides the LGX System – which supports high manipulation frequency and intermediate density – and HDX System – for systems demanding high density and safe connections with low change frequency.

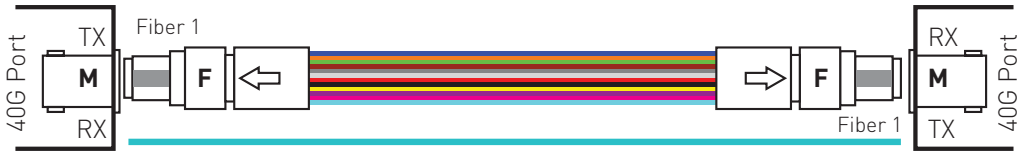


Distinct environments, which need components with different capacities (density).

3.3 POLARITY

The purpose of all optical connectivity methods is the same: to create a communication path between the transmission port of an equipment unit and the receiving port of another equipment unit.

TYPE B



There are different forms of achieving this goal; however, they are not inter-operable. That´s why, we recommend choosing carefully and keeping the same standard during the whole service life of the facility.

3.3.1 STANDARDS

The TIA-568-C standard recognizes three methods for parallel transmission configuration:

TYPE A

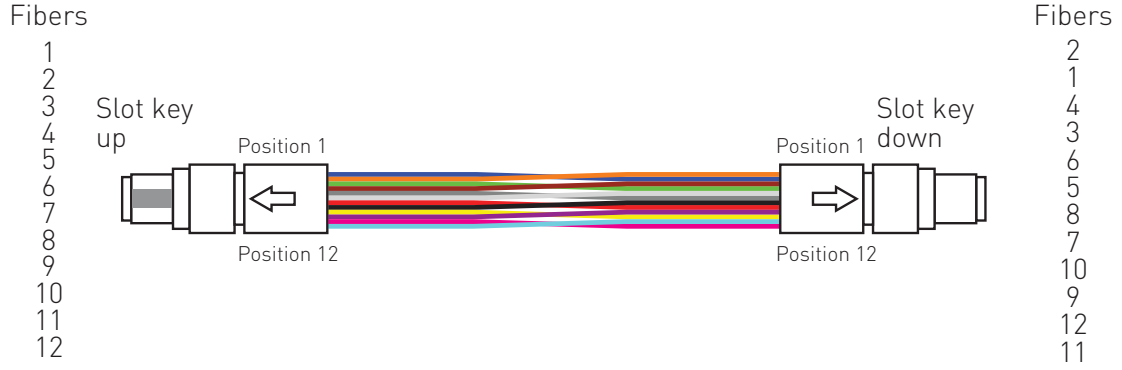
For assembly of trunk cables MPO-MPO of the TYPE A, fiber 1 of one end represents fiber 1 of the other end.

TYPE B

For assembly of trunk cables MPO-MPO of the TYPE B, fiber 1 of one end represents fiber 12 of the other end. In this case, there is total inversion of the fibers.

TYPE C

For assembly of trunk cables MPO-MPO of the TYPE C, fiber 1 of one end represents fiber 2 of the other end. There is inversion per fiber "pair" only (ex. fiber 1 and 2 are considered a pair of fibers, or an optical channel).



3.3.2 IMPORTANCE IN THE PROJECT

Attention: The male/female standard shall always be observed, considering that in general, the equipment is provided with interfaces of the type male, thus, the cords/cables used shall be provided with female connectors.

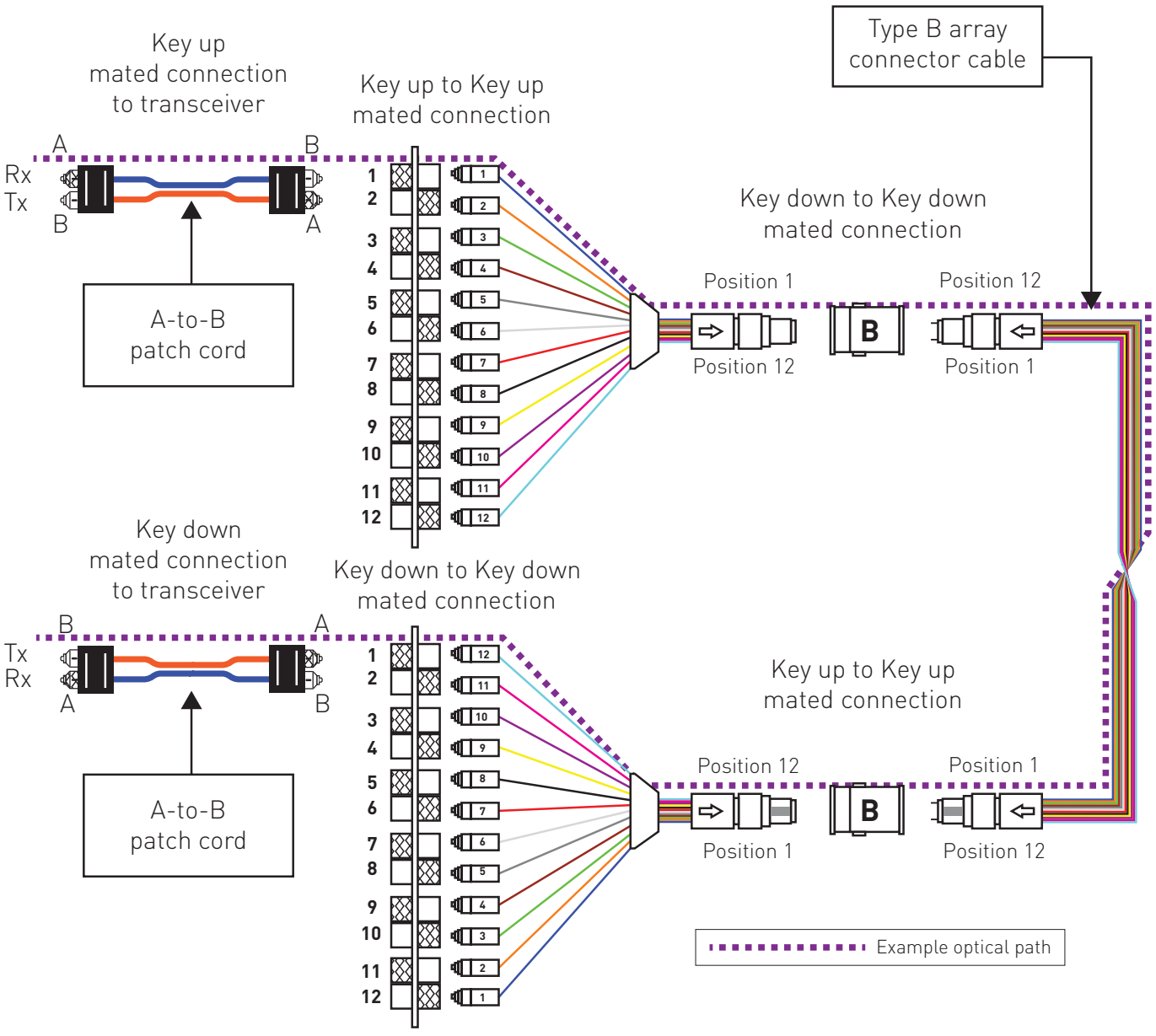
Furukawa understands that the most adequate optic connectivity method is TYPE B.

With all elements of the TYPE B cabling, the future migration of 1/10 G networks to 40/100 G networks is facilitated and thus, standard supply products can be applied.

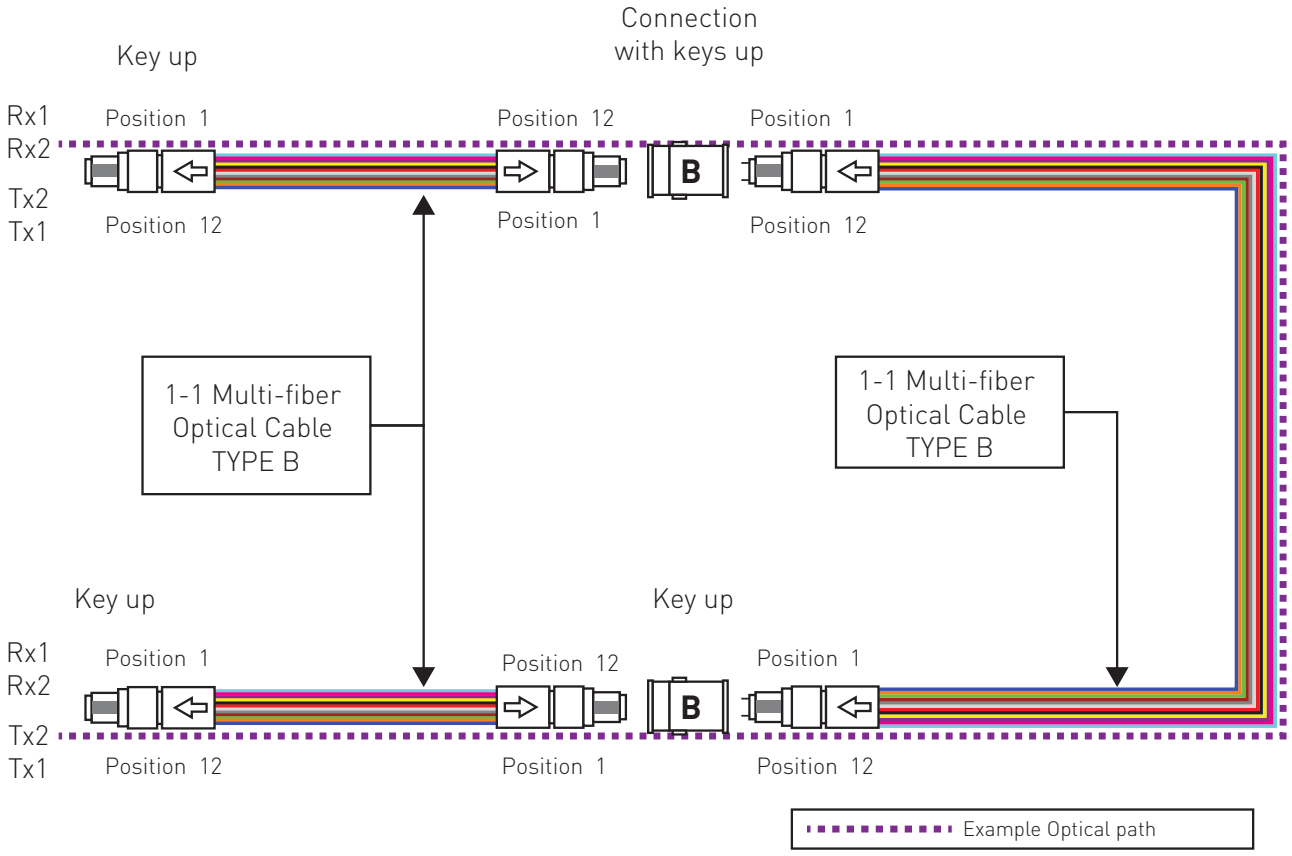
For channels with two or more connections, it is necessary to check:

- The male/female standard for all MPO connections.
- The polarity of the products, having in mind that for 40G transmission, it is necessary to have odd number or 100% TYPE B components in the channel.

According to the representation of the TIA-568-C.0 standard, the 1/10 G channels can be configured in the following way:



When designed for 40 G/100 G networks, the following configuration shall be used:

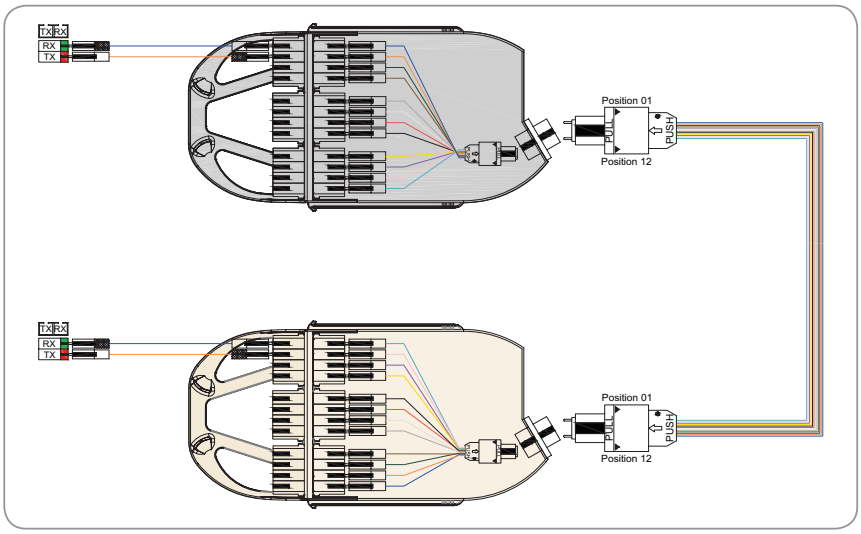


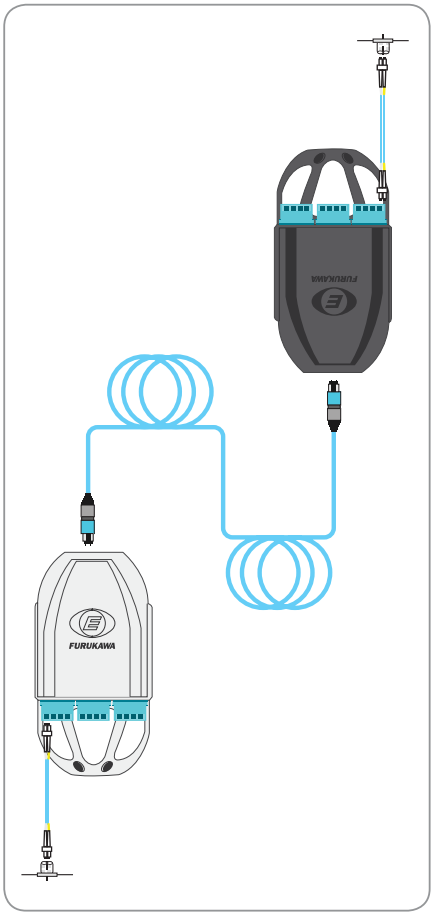
REMARK

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

HDX line is used to implement new channels, where:

- Cassette HDX is mounted with Female MPO;
- The Trunk Cable is mounted with Male MPO and TYPE B polarity;
- To each MPO end shall be connected: one cassette "Direct" and at the respective end on the other side of the cable one cassette "Reverse".





3.4 TOPOLOGIES

In order for all equipment existing in MDA to be connected to the equipment present in EDA, regardless of the size of the Data Center, several topologies can be applied – each one with its advantages and disadvantages. Hereunder, we can see the details of the main topologies applies in the current Data Centers.

3.4.1 CENTRALIZED CROSS-CONNECT

Centralized Switching Architecture TIA-942 Direct Connect (Any-to-All)

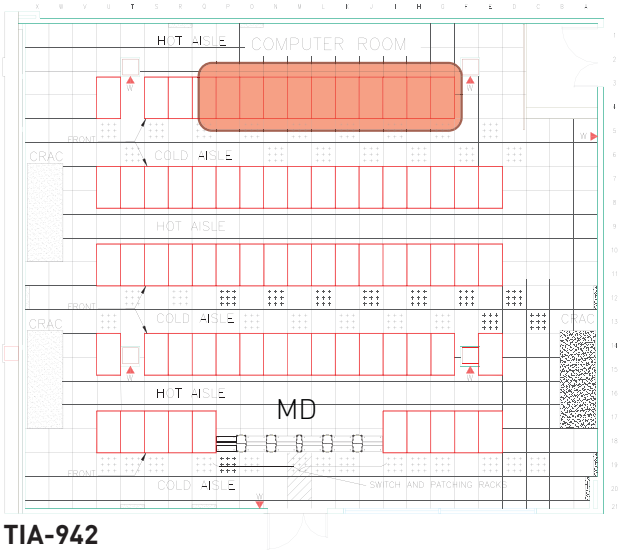
Considerations and points of attention:

- Lower cost of distributed architectures;
- Simple to design, implement and maintain;
- Minimized network bottleneck;
- Good port use;
- Simple device management;
- Higher flexibility for inter-connect or cross-connect topologies;
- As all switches and other network equipment are centralized, the number of active equipment ports necessary for the project is minimized;
- Simplifies the administration of the cabling and the active network equipment;
- Allows intelligent monitoring and administration systems (AIM);
- Reduces the number of monitoring modules, administration modules and a backbone switch ports: "more capacity in less boxes";
- Reduces the power consumption, redundancy and cooling requirements;
- Reduces the length of the equipment cords, even if there is a cross-connect area.
- Easy to implement high availability layouts (redundancy);
- Big number of cables in MDA;
- Overlapped cables in MDA and in the main infrastructure;
- Difficulties in the infrastructure design, due to the high density of optical and copper cabling;
- Non-scalable;
- Higher number of cross-connects to administer and provide maintenance;
- Higher number of cabling links than in the ToR or EoR/MoR options;

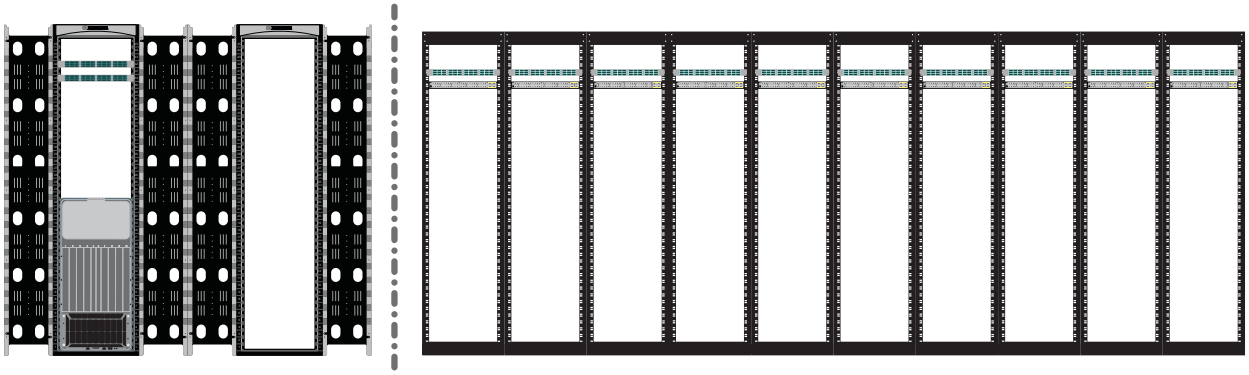
Example 1

Analysis of one row of 10 racks EDAs

IEEE

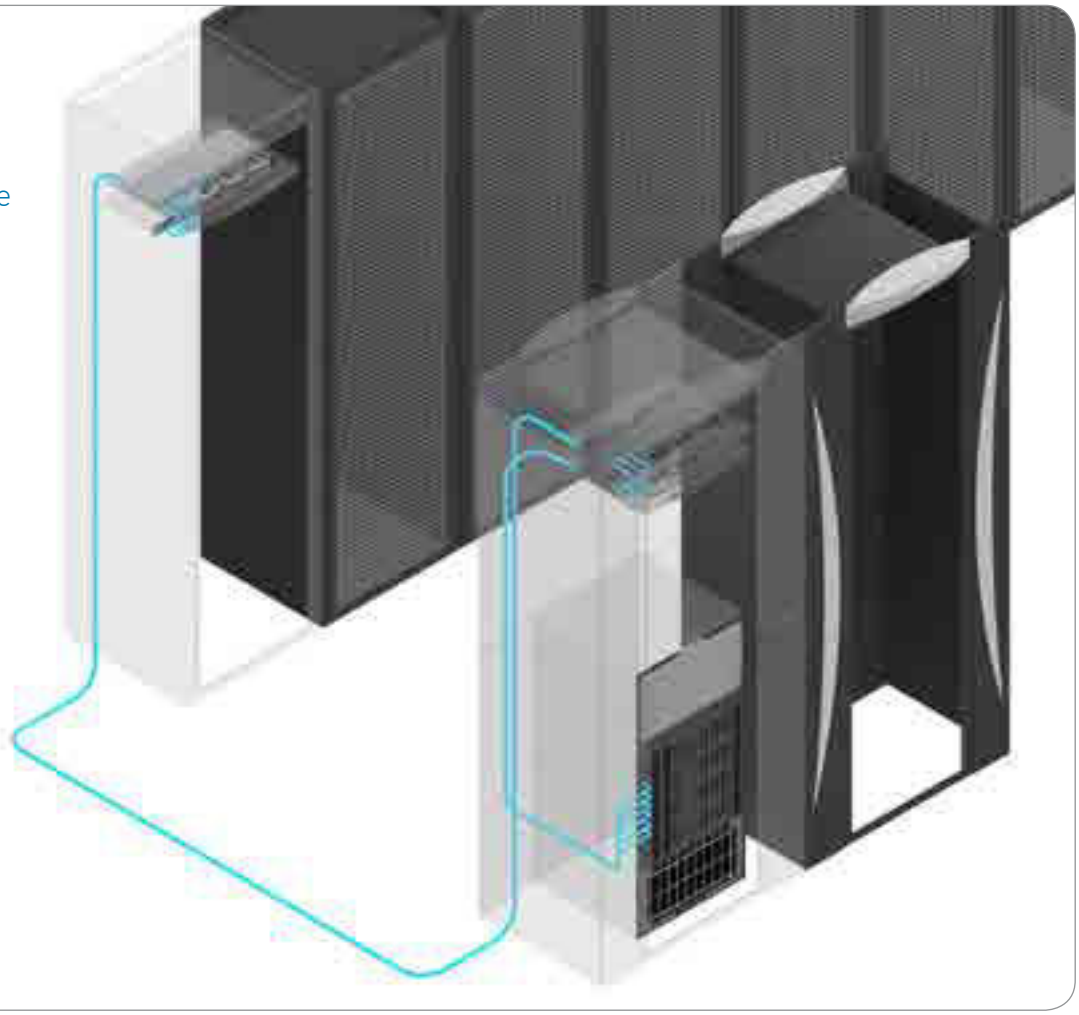


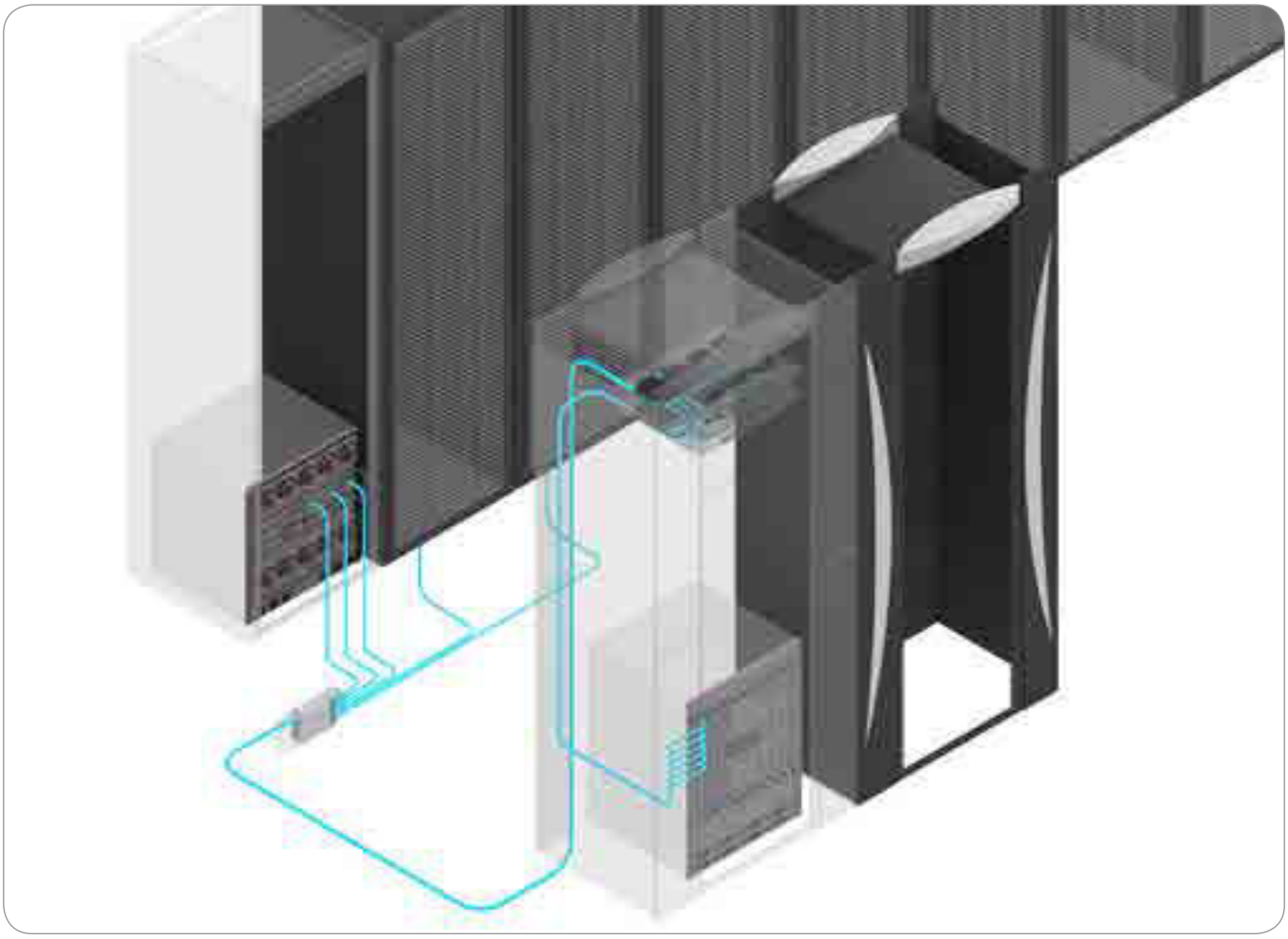
TIA-942



Bay Face of one row 10xEDAs (Server Racks) and 1xMDA

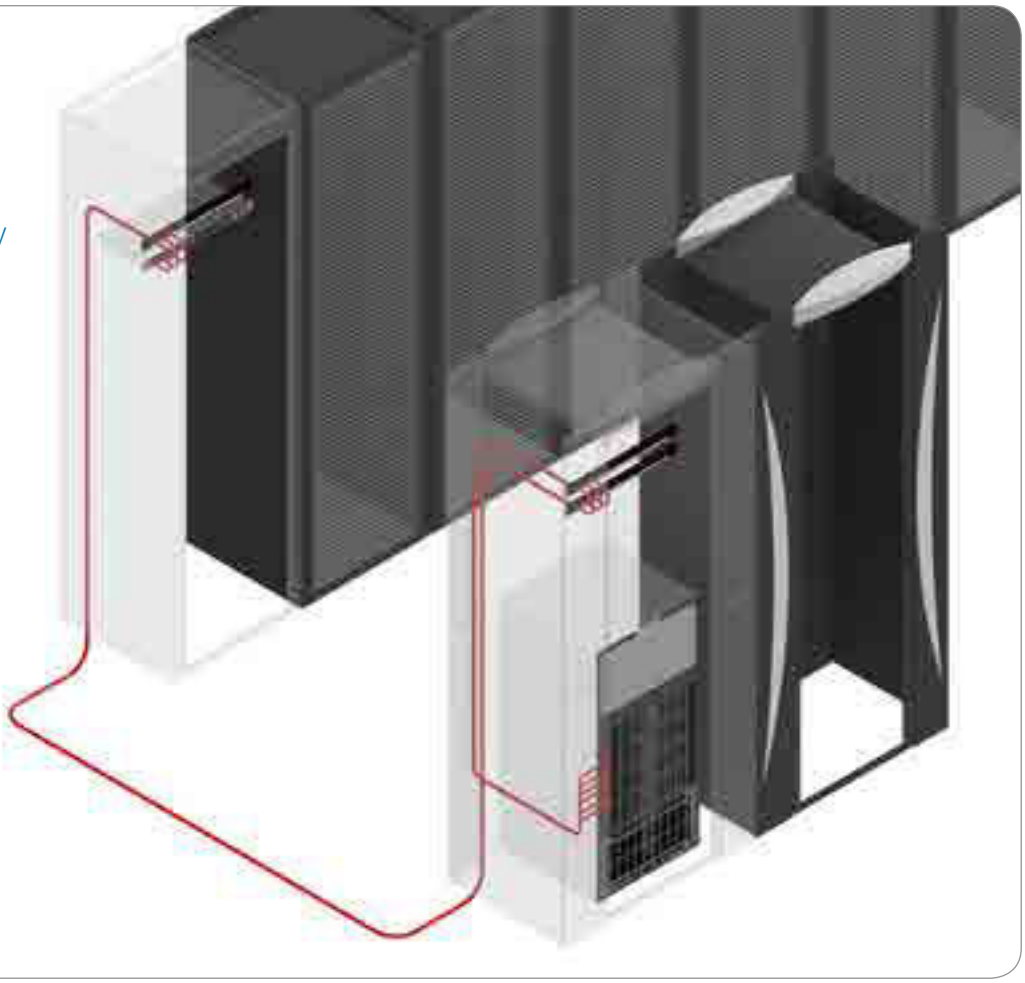
Demonstration of application of optic products necessary to serve a centralized topology, high-density cross-connect.





SAN Networks (Storages)

Demonstration of application of copper products necessary to serve a centralized topology, high-density inter-connect:



List of Materials for Example 1

	Specification	Part Number	Description	EDA	MDA	TOTAL
Optic Cabling	2814	-	Trunk Cable Connectorized 24F OM4 MPO-UPC(M)/ MPO-UPC(M) 1.0D3/1.0D3 35.0 m - TS - LSZH - Type B	4	-	4 parts
	2814	-	Trunk Cable Connectorized 24F OM4 MPO-UPC(M)/MPO-UPC(M) 1.0D3/1.0D3 40.0 m - TS - LSZH - Type B	4	-	4 parts
	2814	33900673	Trunk Cable Connectorized 24F OM4 MPO-UPC(M)/ MPO-UPC(M) 1.0D3/1.0D3 25.0 m - TS - LSZH - Type B	4	-	4 parts
	2814	33900674	Trunk Cable Connectorized 24F OM4 MPO-UPC(M)/ MPO-UPC(M) 1.0D3/1.0D3 30.0 m - TS - LSZH - Type B	4	-	4 parts
	2439	35200918	Duplex Optical Patch Cord MM (50.0) OM4 10 Gigabit LC-UPC/LC-UPC 2.5 m - LSZH - Acqua (A-B)	216	216	432 parts
	2759	35260428	ODF Cassette HDX 12F OM4 LC-UPC/MPO-UPC(F) - Type B - Reverse	36	-	36 parts
	2759	35260429	ODF Cassette HDX 12F OM4 LC-UPC/MPO-UPC(F) - Type B - Direct	-	36	36 parts
	2753	35265003	ODF Modular HDX 1U - Basic Module	9	3	12 parts
Metal Cabling	1641	35085054	F/UTP CAT.6A Patch Cord - GigaLan Augmented - LSZH - T568A/B - 3.0 m - Blue (Shielded)	216	-	216 parts
	2265	23370014	Data Cable GigaLan Augmented F/UTP 23AWGX4P CAT. 6A LSZH (305 m) - Gray	7020	-	7020 m
	2140	35050234	UTP Shielded Modular Patch Panel 24P with Identification Icons (Unloaded)	9	9	18 parts
	2723	35080100	UTP Shielded Modular Jack T568A/B GigaLan Augmented CAT.6A	216	216	432 parts
	1641	35085040	F/UTP CAT.6A Patch Cord - GigaLan Augmented - LSZH - T568A/B - 3.0 m - Gray (Shielded)	-	216	216 parts

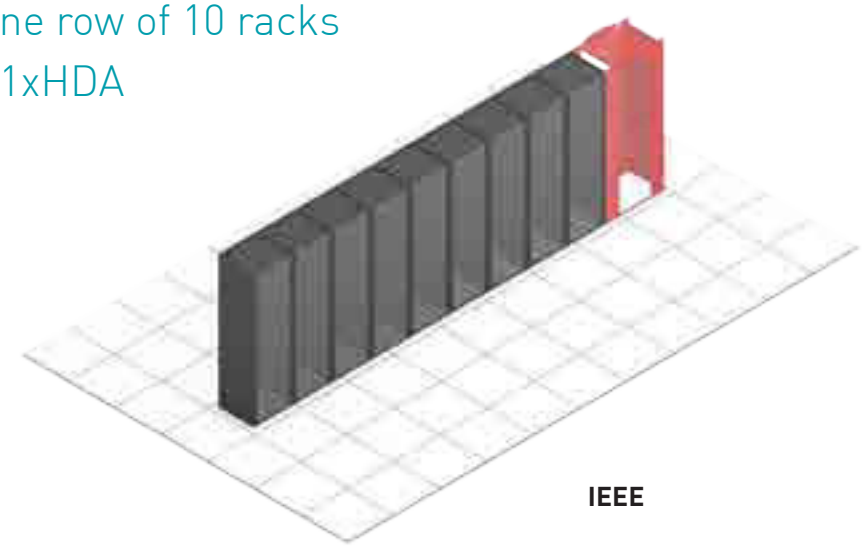
3.4.2 EoR (END OF ROW)

Considerations and points of attention:

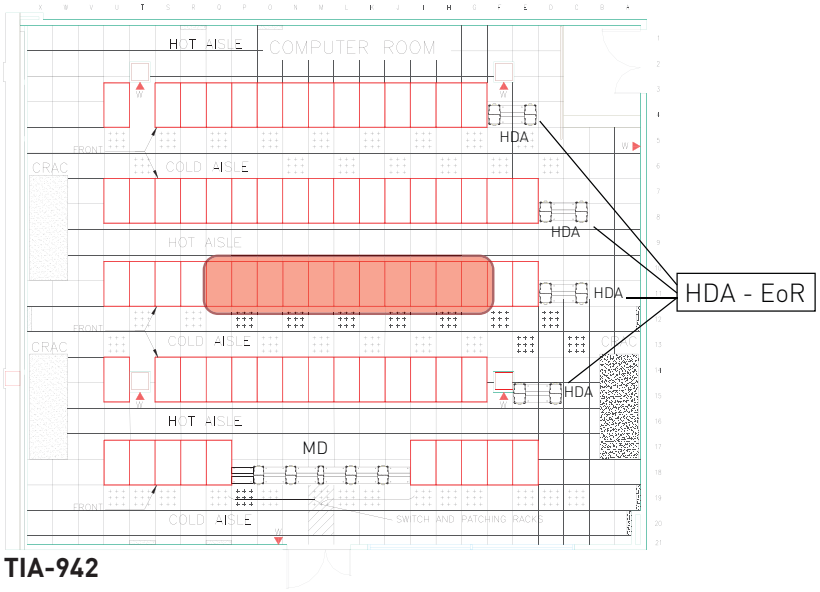
- Lower number of cables than in the architecture with direct connection between HDA and MDA;
- Very good scalability;
- More cost-effective compared to ToR;
- Easy interconnection between servers and network devices;
- Fast insertion of new hardware in racks and in the network;
- Very low cabling density, reducing the required space in the infrastructure under technical floor;
- Quick installation;
- Less space required in the cabling distribution racks;
- Interfaces and patch cords for servers with good cost x benefit ratio;
- Excess of switches and network ports spread throughout the Data Center.

Example 2

Analysis of one row of 10 racks
9xEDAs and 1xHDA



IEEE



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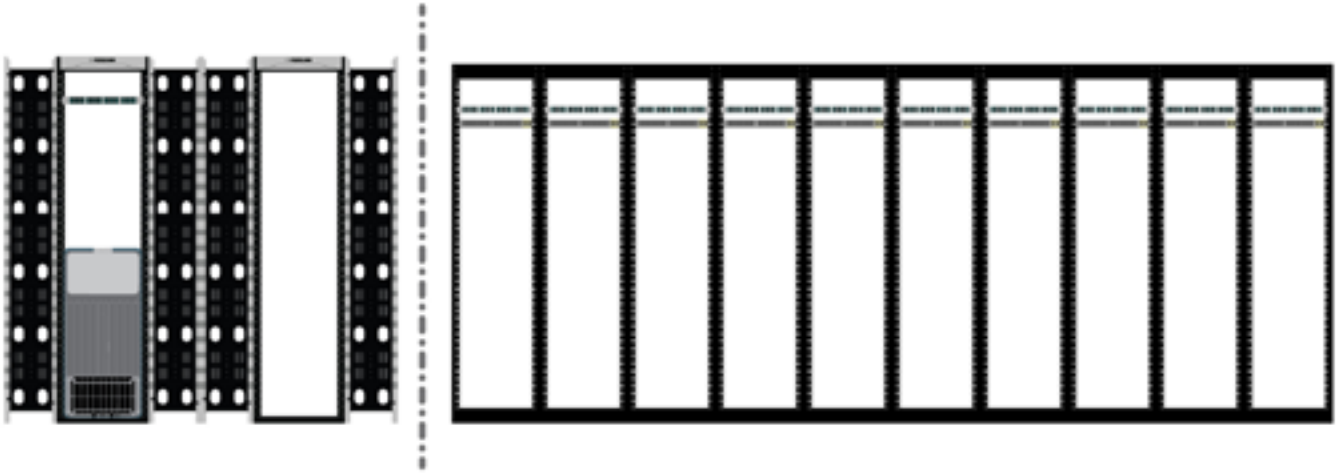
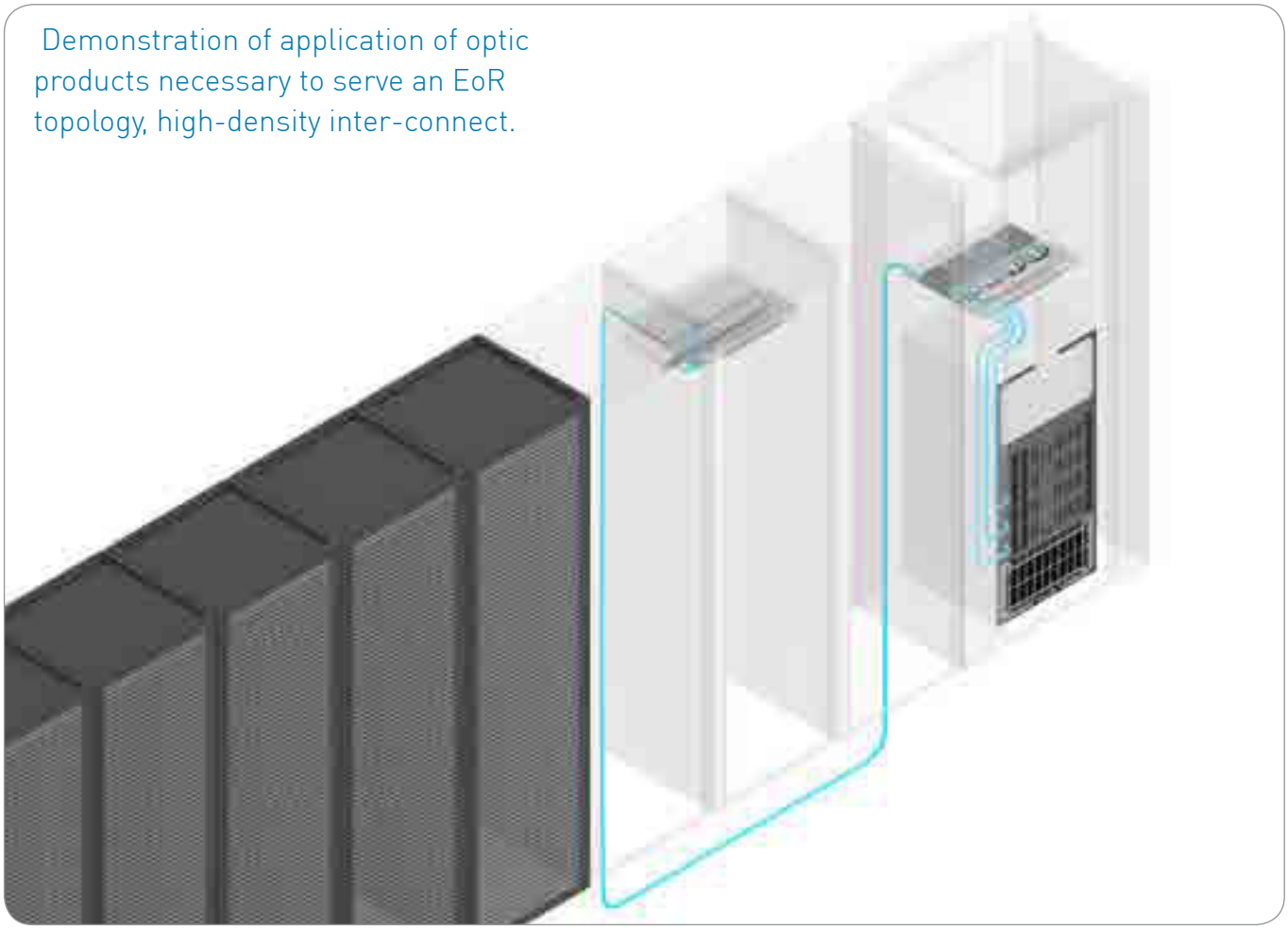
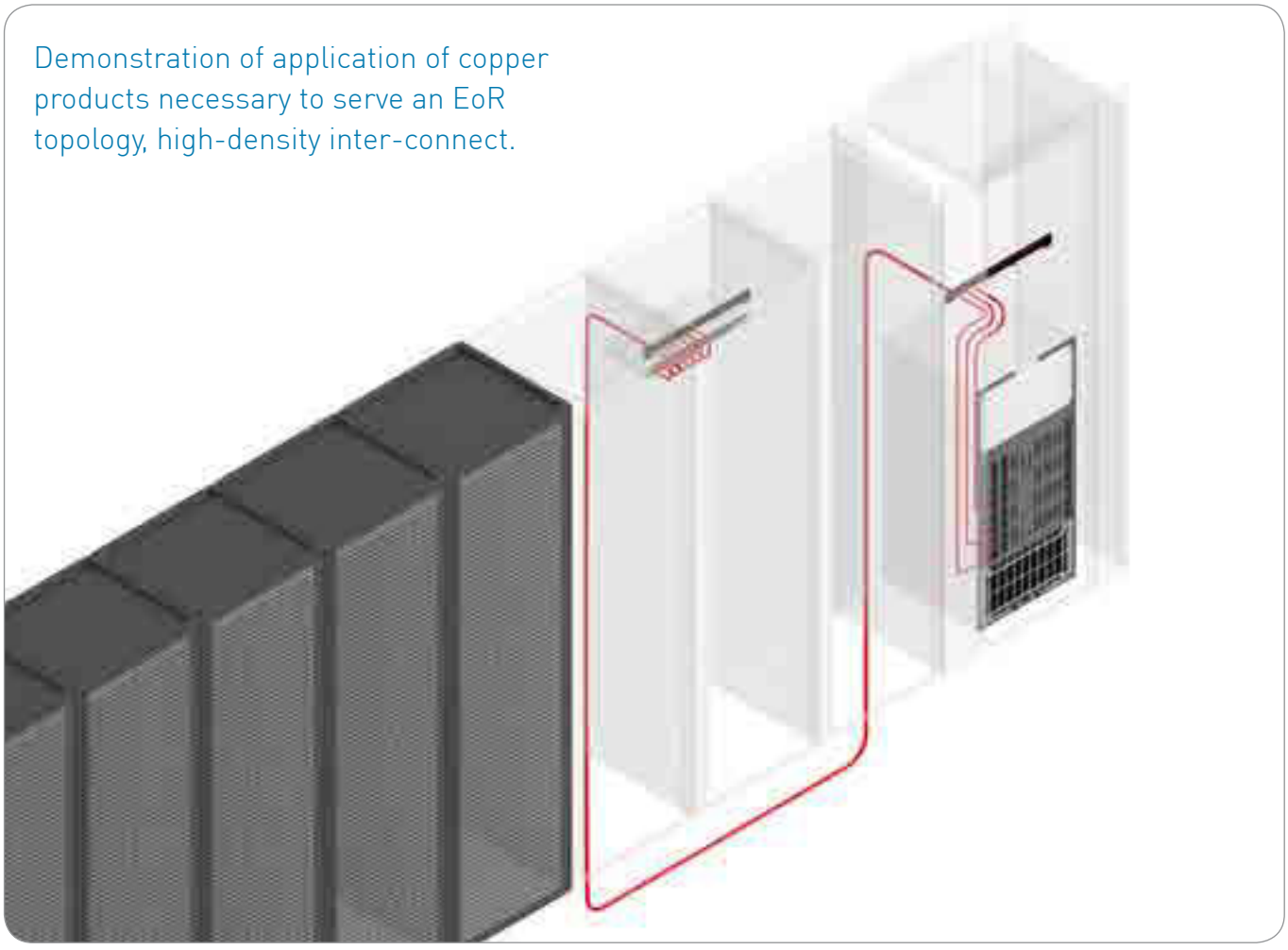


Bay Face of one 10 Racks row: 9xEDAs (Server Racks) and 1xHDA (EoR)

Demonstration of application of optic products necessary to serve an EoR topology, high-density inter-connect.



Demonstration of application of copper products necessary to serve an EoR topology, high-density inter-connect.



List of Materials for Example 2

	Specifi-cation	Part Number	Description	EDA	HDA	TOTAL
Optic Cabling	2814	-	Trunk Cable Connectorized 24F OM4 MPO-UPC(M)/ MPO-UPC(M) 1.0D3/1.0D3 10.0 m - TS - LSZH - Type B	4	-	4 parts
	2814	33900671	Trunk Cable Connectorized 24F OM4 MPO-UPC(M)/ MPO-UPC(M) 1.0D3/1.0D3 15.0 m - TS - LSZH - Type B	4	-	4 parts
	2814	33900672	Trunk Cable Connectorized 24F OM4 MPO-UPC(M)/ MPO-UPC(M) 1.0D3/1.0D3 20.0 m - TS - LSZH - Type B	4	-	4 parts
	2814	33900673	Trunk Cable Connectorized 24F OM4 MPO-UPC(M)/ MPO-UPC(M) 1.0D3/1.0D3 25.0 m - TS - LSZH - Type B	4	-	4 parts
	2439	35200918	Duplex Optical Patch Cord MM (50.0) OM4 10 Gigabit LC-UPC/LC-UPC 2.5 m - LSZH - Acqua (A-B)	216	216	432 parts
	2759	35260428	ODF Cassette HDX 12F OM4 LC-UPC/MPO-UPC(F) - Type B - Reverse	36	-	36 parts
	2759	35260429	ODF Cassette HDX 12F OM4 LC-UPC/MPO-UPC(F) - Type B - Direct	-	36	36 parts
	2753	35265003	ODF Modular HDX 1U - Basic Module	9	3	12 parts
Copper Cabling	1641	35085054	F/UTP CAT.6A Patch Cord - GigaLan Augmented - LSZH - T568A/B - 3.0 m - Blue (Shielded)	216	-	216 parts
	2265	23370014	Data Cable GigaLan Augmented F/UTP 23AWGX4P CAT. 6A - LSZH (305 m) - Gray	3780	-	3780 m
	2140	35050234	UTP Shielded Modular Patch Panel 24P with Identification Icons (Unloaded)	9	9	18 parts
	2723	35080100	UTP Shielded Modular Jack T568A/B GigaLan Augmented CAT.6A	216	216	432 parts
	1641	35085040	F/UTP CAT.6A Patch Cord - GigaLan Augmented - LSZH - T568A/B - 3.0 m - Gray (Shielded)	-	216	216 parts

3.4.3 MoR (MIDDLE-OF-ROW)

The HDA rack is centralized in the server rack row, and the horizontal network cabling serves all EDAs racks in an equidistant way.

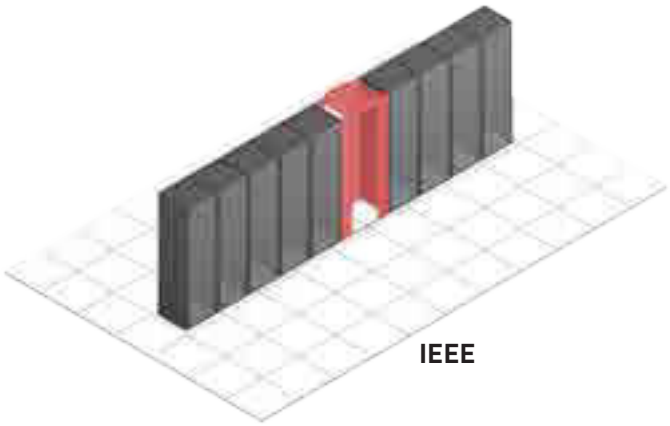
Considerations and points of attention:

- Cables with shorter physical length;
- Lower number of cables than for the direct connection architecture;
- Good scalability;
- Cost-effective compared to ToR;
- Relatively easy to mount server interconnection to network assets;
- Quick addition of new equipment;
- Very low cabling density, which reduces the need of space under technical floor or in the infrastructure;
- Quick installation;
- Reduced space for cabling distribution racks;
- Interfaces and patch cords for servers with good cost x benefit ratio;
- Does not require many network ports as in the ToR architecture;
- Higher cost of assets (switches) in the rack MoR;
- Increase of management overload.

- Network stability at risk due to potential loop of layer 2, which causes transmission jam;
- Broadcast storm;
- Reasonable excess of equipment and network ports;
- Administration and maintenance separate in each group of racks;
- Flexibility limited to the services offered by the MoR switch;
- Network segmentation only by virtual means (VLAN, Fabric SAN), which may oppose the existing information security policies;
- Additional need of cooling and power in each group of racks;
- Unless the networks are 100% integrated, it shall be complemented with other cabling diagrams for SAN, redundancies, consoles, security and management networks, etc.
- It does not allow intelligent monitoring and administration of cabling for server connection;
- The interconnection between different racks of the same row requires very long cables, which may lead to raising many technical floor plates, which, in addition to delaying the implementation, places active networks points at risk of stoppage;
- The interconnection between racks of the same row, may lead to opening of the racks, which are between the racks to be interconnected, which may oppose the existing customer´s information security policy.

Example 3

Analysis of one row of 10 racks 10xEDAs and 1xHDA (MoR)



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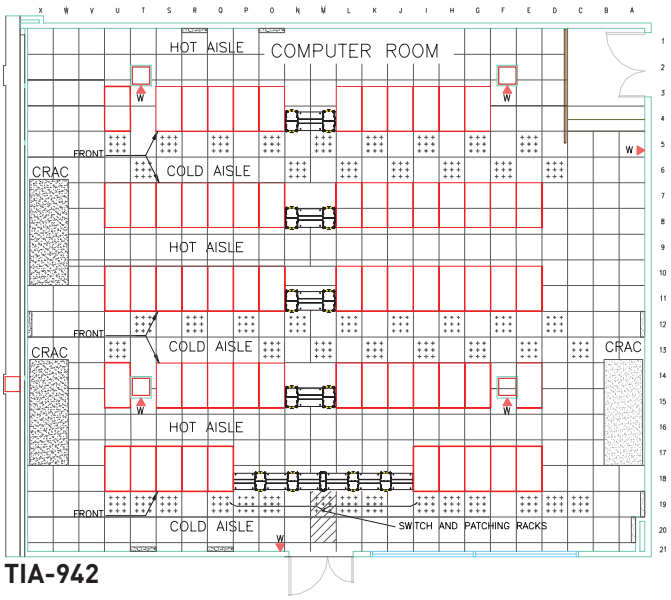

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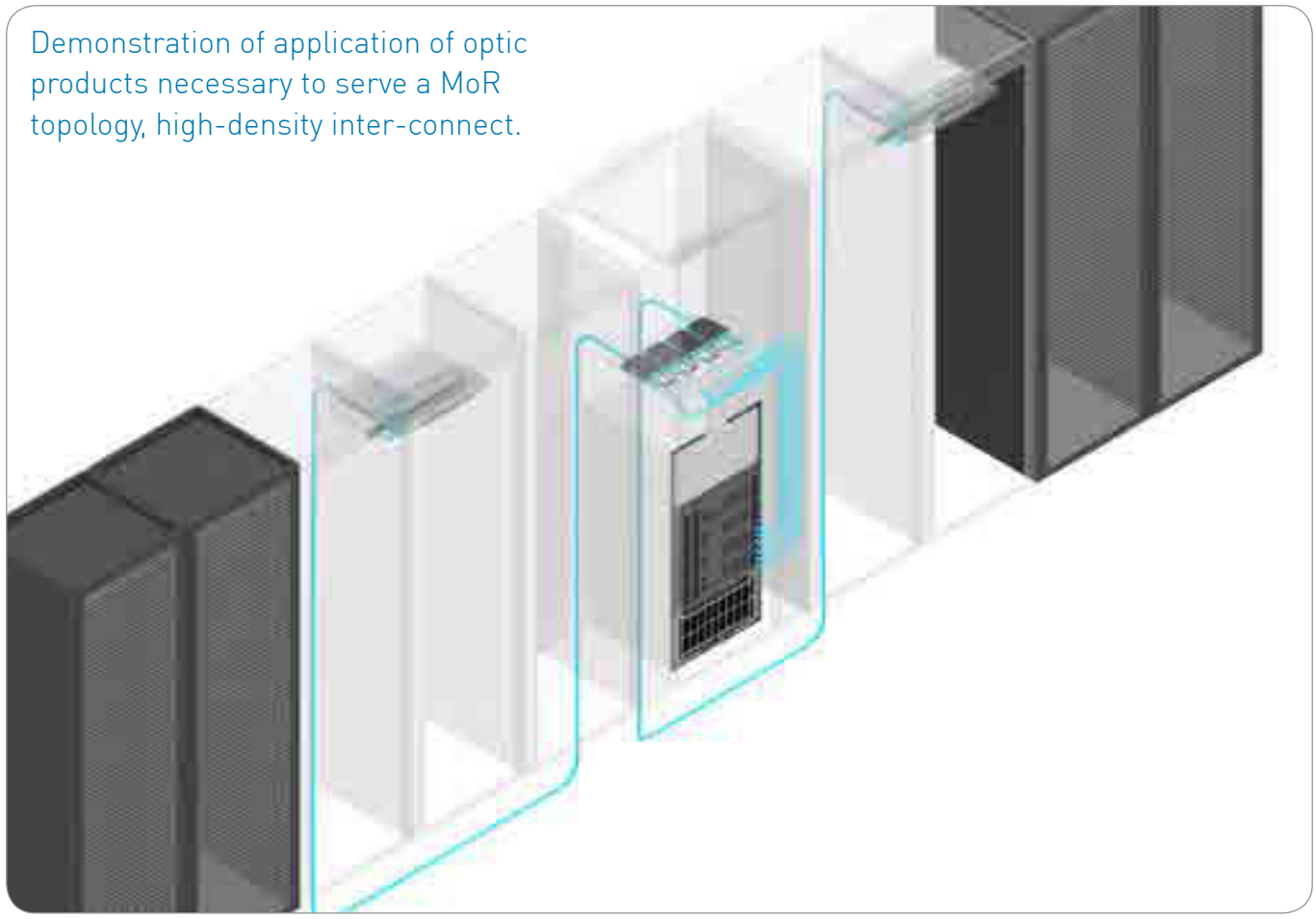
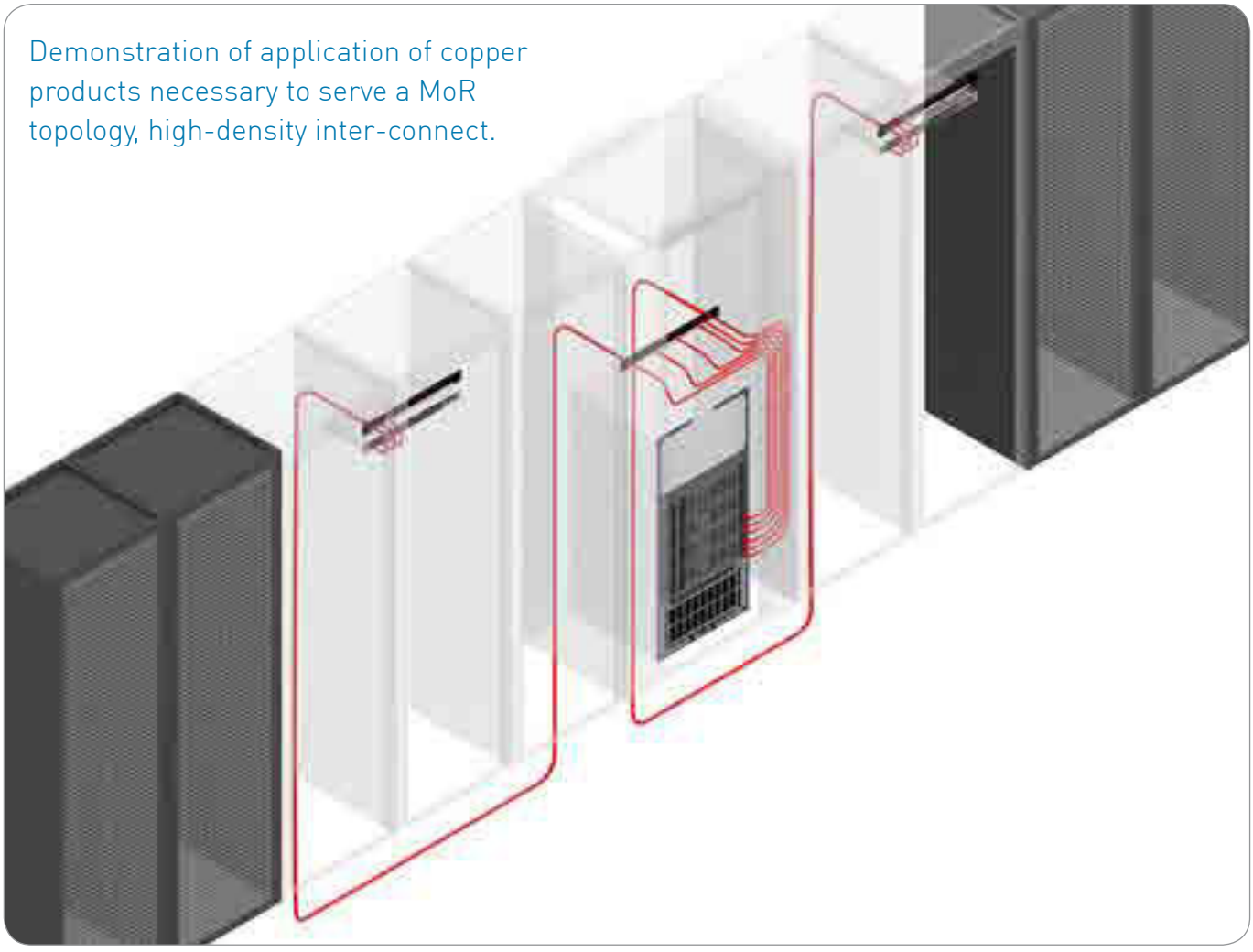
Bay Face of one 10 Racks row: 9xEDAS (Server Racks) and 1xHDA (MoR)

Demonstration of application of optic products necessary to serve a MoR topology, high-density inter-connect.



Demonstration of application of copper products necessary to serve a MoR topology, high-density inter-connect.



List of Materials for Example 3

	Specification	Part Number	Description	EDA	HDA	TOTAL
Optic Cabling	2814	-	Trunk Cable Connectorized 24F OM4 MPO-UPC(M)/ MPO-UPC(M) 1.0D3/1.0D3 10.0 m - TS - LSZH - Type B	9	-	9 parts
	2814	33900671	Trunk Cable Connectorized 24F OM4 MPO-UPC(M)/ MPO-UPC(M) 1.0D3/1.0D3 15.0 m - TS - LSZH - Type B	9	-	9 parts
	2439	35200918	Duplex Optical Patch Cord MM (50.0) OM4 10 Gigabit LC-UPC/LC-UPC 2.5 m - LSZH - Acqua (A-B)	216	216	432 parts
	2759	35260428	ODF Cassette HDX 12F OM4 LC-UPC/MPO-UPC(F) - Type B - Reverse	36	-	36 parts
	2759	35260429	ODF Cassette HDX 12F OM4 LC-UPC/MPO-UPC(F) - Type B - Direct	-	36	36 parts
	2753	35265003	ODF Modular HDX 1U - Basic Module	9	3	12 parts
Copper Cabling	1641	35085054	F/UTP CAT.6A Patch Cord - GigaLan Augmented - LSZH - T568A/B - 3.0 m - Blue (Shielded)	216	-	216 parts
	2265	23370014	Data Cable GigaLan Augmented F/UTP 23AWGX4P CAT. 6A - LSZH (305 m) - Gray	3780	-	3780 m
	2140	35050234	UTP Shielded Modular Patch Panel 24P with Identification Icons (Unloaded)	9	9	18 parts
	2723	35080100	UTP Shielded Modular Jack T568A/B GigaLan Augmented CAT.6A	216	216	432 parts
	1641	35085040	F/UTP CAT.6A Patch Cord - GigaLan Augmented - LSZH - T568A/B - 3.0 m - Gray (Shielded)	-	216	216 parts

3.4.4 ToR (TOP-OF-RACK)

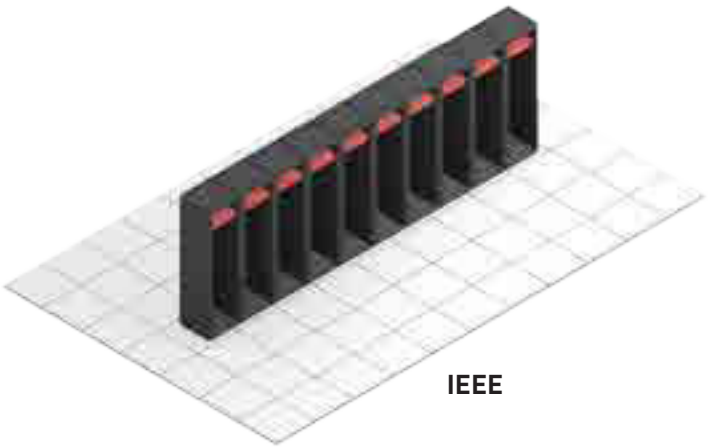
Considerations and points of attention:

- Most of them use more efficient cabling;
- Efficient use of space;
- Good scalability;
- Easy cable management;
- Easy interconnection of servers and ToR switches;
- Quick addition of new equipment;
- Very low cabling density, which reduces the need of space under the technical floor;
- Quick installation;
- The space required for the cabling distribution racks is small;
- Interfaces and server connection cables for ToR switches do not have attractive cost x benefit ratio as the structured cabling patch cords;
- More options to manage active network equipment;
- Higher number of AGG ports (SW Aggregation or distribution);
- Higher number of STP ports in AGG;
- More server-to-server traffic in AGG;
- High cost of assets (switches);
- Thermal management risk;
- Creation of hotspots;

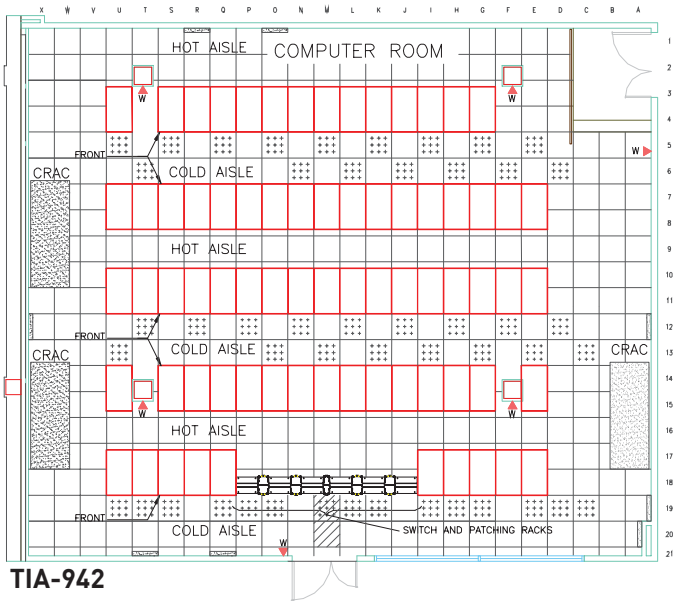
- Excess of equipment and network ports;
- Administration and maintenance separate in each rack with ToR switch, which increases the complexity of the network and reduces its reliability;
- Flexibility limited to the services offered by the ToR switches;
- Network segmentation only by virtual means (VLAN, Fabric SAN), which may oppose the information security policies existing at the customer;
- Necessity of additional cooling and power in each group of racks with ToR switch;
- The implementation of high availability layouts is difficult and expensive;
- Requires big number of links and redundant resources, such as power supplies, administration modules and backbone ports;
- Unless the networks are 100% integrated, it shall be complemented with other cabling layouts for SAN, redundancies, consoles, security and management networks, etc.
- It does not allow intelligent monitoring and administration of cabling for server connection;
- It does not comply with the structured cabling standards, as there is no horizontal cabling and it requires direct connections between access switches (edge) and servers mounted on adjacent or distant racks in the same row.

Example 4

Analysis of one row of 10 racks – 10xEDAs with Switch Core centralization outside the server room.



IEEE



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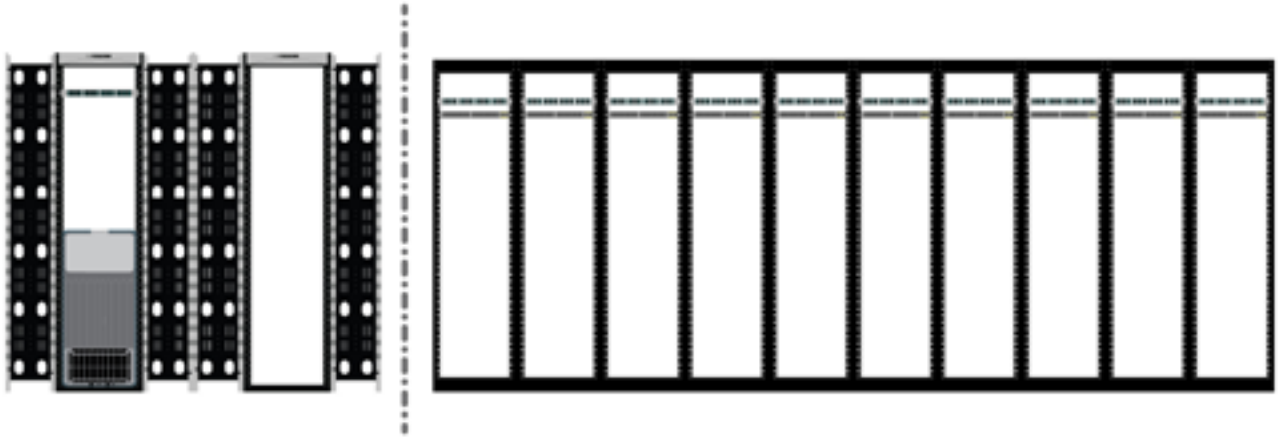
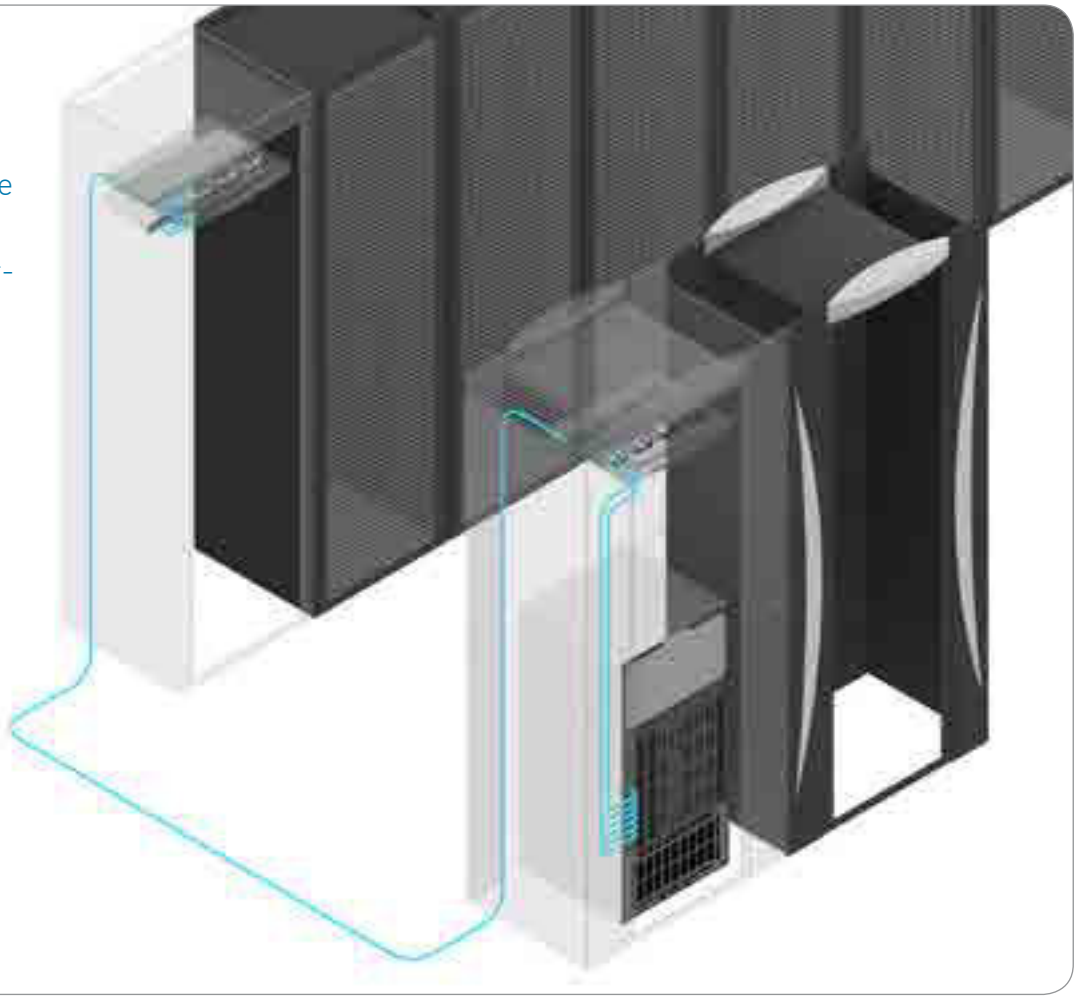


Bay Face of one 10 Rack row: 9xEDAs ToR (server racks) and 1xMDA

Demonstration of application of optic products necessary to serve a ToR topology, high-density inter-connect



List of Material for Example 4

	Specification	Part Number	Description	EDA	MDA	TOR	TOTAL
Optic Cabling	2814	-	Trunk Cable Connectorized 24F OM4 MPO-UPC(M)/MPO-UPC(M) 1.0D3/1.0D3 35.0 m - TS - LSZH - Type B	4	-	-	4 parts
	2814	-	Trunk Cable Connectorized 24F OM4 MPO-UPC(M)/MPO-UPC(M) 1.0D3/1.0D3 40.0 m - TS - LSZH - Type B	4	-	-	4 parts
	2814	33900673	Trunk Cable Connectorized 24F OM4 MPO-UPC(M)/MPO-UPC(M) 1.0D3/1.0D3 25.0 m - TS - LSZH - Type B	4	-	-	4 parts
	2814	33900674	Trunk Cable Connectorized 24F OM4 MPO-UPC(M)/MPO-UPC(M) 1.0D3/1.0D3 30.0 m - TS - LSZH - Type B	4	-	-	4 parts
	2439	35200918	Duplex Optical Patch Cord MM (50.0) OM4 10 Gigabit LC-UPC/LC-UPC 2.5 m - LSZH - Acqua (A-B)	216	216	432	864 m
	2759	35260428	ODF Cassette HDX 12F OM4 LC-UPC/ MPO-UPC(F) - Type B - Reverse	36	-	-	36 parts
	2759	35260429	ODF Cassette HDX 12F OM4 LC-UPC/ MPO-UPC(F) - Type B - Direct	-	36	-	36 parts
	2753	35265003	ODF Modular HDX 1U - Basic Module	9	3	-	12 parts
Copper Cabling	1641	35085040	F/UTP CAT.6A Patch Cord - GigaLan Augmented - LSZH - T568A/B - 3.0 m - Gray (Shielded)	-	-	432	432 parts

3.5 PROJECT ASSUMPTIONS

The most adequate form to build a high-speed network Ethernet or SAN will depend on the type of topology selected, the involved distances and the interfaces of the equipment available. We have elaborated a simplified checklist, which will help the integrator/designer and the final customers to elaborate the cabling project assumptions:

Standard(s) Defined for the Project:	Cabling:
	Electric Network:
	Grounding:
	Infrastructure:
	Administration/Identification:
Solution:	Copper ( )
	Optical ( )
	Intelligent ( )
Cabling Topology:	Interconnect ( )
	Cross-connect ( )
	Point-to-Point ( )
Data Center Topology:	Reduced (MDA/ZDA/EDA)
	Basic (EF/TR/MDA/HDA/ZDA/EDA)
	Distributed (EF1/EF2/TR/MDA/IDA/HDA/ZDA/EDA)
Redundancy Diagram (TIA-942-A:March/2014):	Basic I ( )
	Redundant Component II ( )
	Concurrently Maintainable III ( )
	Fault Tolerant IV ( )
Network Architecture (Logic Network):	ToR ( )
	EoR ( )
	MoR ( )
General Project Volumetry:	Copper Network ( ) points
	Optical Network ( ) points
Volumetry per EDA Rack and other Centralizations (HDA/MDA/IDA/EF/TR)	Detail optical and copper points/racks in a worksheet
TEAM Rating:	Telecommunication ( )
	Electric ( )
	Architecture ( )
	Mechanical ( )
Logic Network Diagram (Network/Network Assets/Switches & Routers):	
Floor and/or Architecture Plan of the Server Room and the Other Environments (with technical floor grid):	
Worksheet with quantity of Ports and Networks:	
Details of the Technical Floor	Existing or new?
	Height?
	Anti-static?
	Load withstand (kg)?
	Is it grounded?
Is the Data Center building new or existing?	
Photos of all possible environments:	
Is the existing building provided with grounding? (If yes, please share the measurement report for the last year (PIE) and the project as-built)	
If there is not, it's recommended to measure before starting the implementation, to record data with the customer and provide the necessary repair. (Poor grounding may damage the network and it is considered bad use of the cabling.)	
Is the infrastructure existing? If yes, describe what type is, dimensions, current occupation.	
Check the positioning/general state of preservation (for existing networks) of hydraulic firefighting networks, sewage, air conditioning and consumption of the building. Recommendation: there cannot be passage, connection, boxes, etc. inside the technical rooms.	

3.5.1 OPTIC POWER BUDGET

A point of extreme importance, mainly for high-speed applications 10/40/100 Gbps, the optic power budget serves to determine whether the designed optical link will fulfill the requirements of the current applications intended by the project and the future applications, which may run in this cabling.

The maximum optic attenuation parameter is fundamental for optical channel designs in Data Centers, because it defines the proposed optical network topology and whether the physical components are suitable for the design. In case of need to change, the replacement of physical termination and connection components, optical cables, type of optical fiber used, as well the infrastructure of this cabling routing and/or its respective physical channel component arrangement are estimated.

Two elementary noting routines and the calculation of these quantities with direct field application and which can help either the network analysts – with focus on active equipment and/or high-speed optic interfaces (Transceivers, Gbics, SFP Mini-Gbics) – or the infrastructure analysts for maintenance situations, are presented below. This also helps the designers for the concept of links for new high-speed optical networks or for expansion of such networks existing in current Data Centers.

Cable attenuation provision (dB)	Cable Attenuation Coefficient [Maximum] **X** Link Length
+ Connector attenuation provision due to Insertion Loss (dB)	Number of Connector Pair **X** Insertion Loss of the Connector
+ Attenuation provision due to Loss in Splice (dB)	Number of Splices **X** Splice Attenuation
General attenuation provision of the Optical Link (dB)	

The typical values of each cabling element can be found in the supplier´s technical specification documents.

3.6.1 OPTICAL CABLING

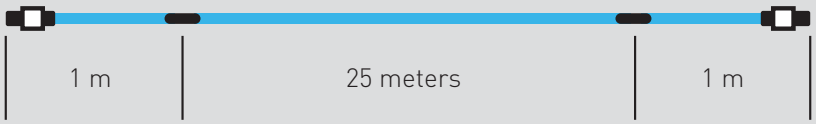
3.6.1.1 Pre-Terminated Optical Cables

Pre-terminated optical cables provides simpler and faster installation in plug-and-play systems, easy to expand and handle.

Adequate pre-terminated cables for permanent link areas

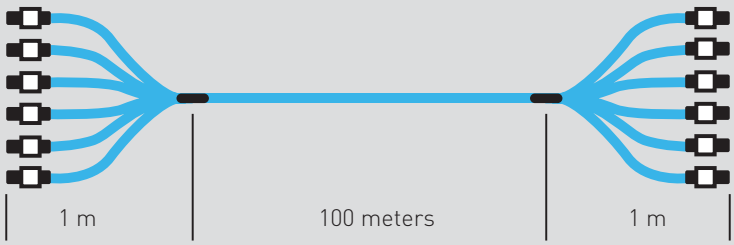
Pre-Terminated MPO Trunk Cable

PRE-TERMINATED TRUNK CABLE 12F OM4 MPO-UPC(M)/MPO-UPC(M) 1.0D3/1.0D3 25.0 m UT – LSZH – TYPE B



- 12 fibers optical cable (SM, OM3 or OM4) with 1 MPO connector of 12 fibers at each end;
- Rated outer diameter 5.5 mm;
- Length from 15 to 200 m;
- Flammability class COG with LSZH cover;
- Assembled and tested in factory. The test report can be checked via web using the cable serial number.

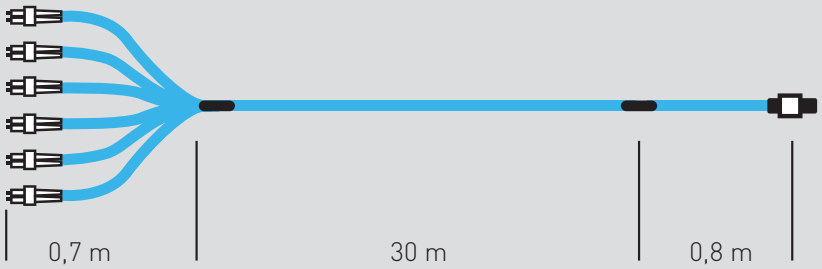
PRE-TERMINATED TRUNK CABLE 72F OM4 MPO-UPC(M)/MPO-UPC(M) 1.0D3/1.0D3 100.0 m – TS LSZH – TYPE B



- Cable composed of 72 fibers (SM, OM3 or OM4) with 6 MPO connectors of 12 fibers at both ends;
- Rated outer diameter 10.0 mm;
- Length from 15 to 200 m;
- Flammability class COG with LSZH cover;
- Assembled and tested in factory. The test report can be checked via web using the cable serial number.

Pre-Terminated Trunk Cable MPO/LC

PRE-TERMINATED TRUNK CABLE FANOUT 12F OM3 LC-UPC/MPO-UPC(F) 0.7D2/0.8D3 30.0 m UT – LSZH



- 12-fiber optical cable (SM, OM3 or OM4) with 1 MPO connector of 12 fibers at one end and 6 LC duplex or 12 SC connectors at the opposite end;
- Rated outer diameter 5.5 mm;
- Length from 15 to 200 m;
- Flammability class COG with LSZH cover;
- Assembled and tested in factory. The test report can be checked via web using the cable serial number.

***REMARK**: male or female connector will be defined according to the cabling project.

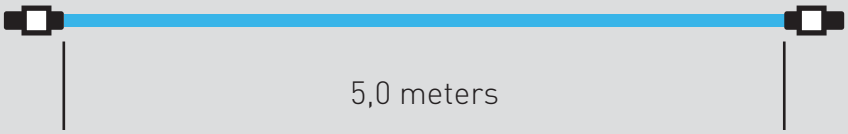
3.6.1.2 Pre-Terminated Optical Cords

Pre-Terminated Optical Patch Cord adequate for Maneuver Areas

DUPLEX OPTICAL CORD MM (50.0) OM4 LC-UPC/LC-UPC 2.5 m – ACQUA – LSZH – (A – B)

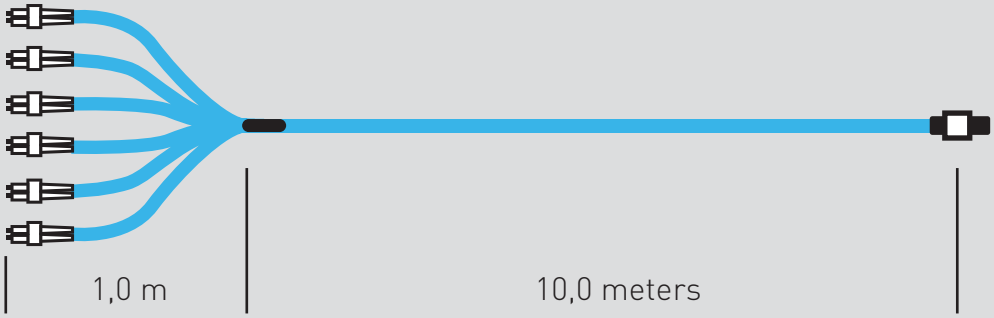
- Uses "zip-cord" standard for fiber reunion (SM, OM3 or OM4);
- With 2 fibers (SM, OM3 or OM4);
- Option for ST/ FC / SC / MT-RJ/ LC connectors at both ends;
- Rated outer diameter 2.0 mm;
- Length from 1 to 20 m;
- Assembled and tested in factory.

MPO OPTICAL CORD OM4 MPO-UPC(F)/MPO-UPC(F) 5.0D3 – MTF – LSZH – TYPE B



- Indoor 12-fiber optical cable (SM or OM4) with 1 MPO connector of 12 fibers at each end;
- Rated outer diameter 3.0 mm;
- Length from 1 to 20 m;
- Assembled and tested in factory. The test report can be checked via web using the cable serial number.

FANOUT OPTICAL CORD OM4 LC-UPC/MPO-UPC(F) 1.0D2/10.0D3 – MTF – LSZH – TYPE B



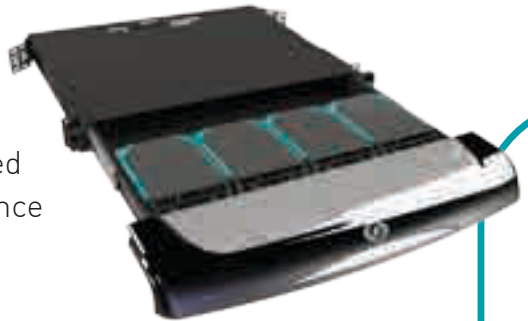
- Indoor 12-fiber optic cable (SM or OM4) with 1 MPO connector of 12 fibers at one end and 06 LC duplex or 12 SC connectors at the opposite end;
- Rated outer diameter 3.0 mm;
- Length from 1 to 20 m;
- Assembled and tested in factory. The test report can be checked via web using the cable serial number.

***REMARK**: male or female connector will be defined according to the cabling project.

3.6.1.3 HDX System

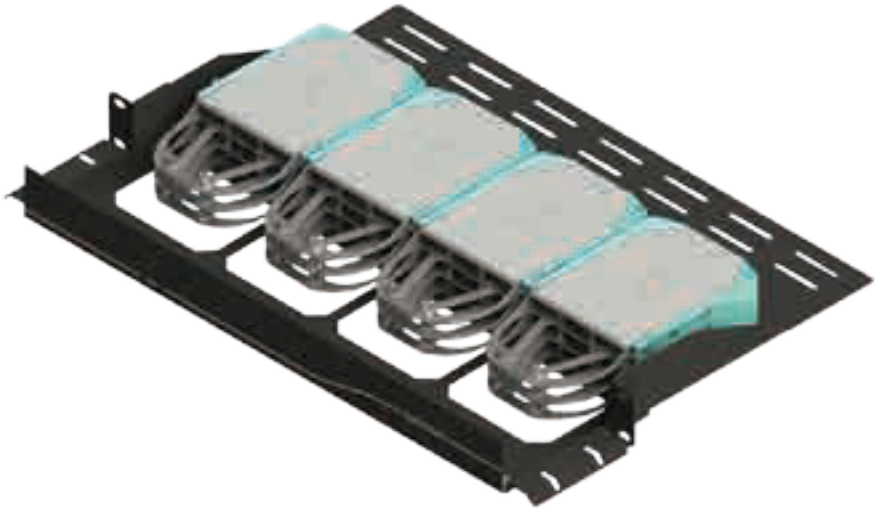
Optical Distribution Frame for HDX Cassettes

- Serves up to 144 fibers in 1U trough 12 pre-terminated cassettes MPO/MTP piled 3 by 3, in a modular and progressive way;
- Sliding drawer with rail system, which facilitates maintenance/installation and further works without removing them from the rack;
- Provided with areas for storage of excess fibers with integrated presence of an organizer, which guarantees the compliance with the bending radius of the installed fibers.



Patch Panel for HDX Cassettes

- Optical panel with capacity for 12 cassettes pre-terminated in 1U in a modular and progressive way;
- Back anchorage system of the pre-terminated cables;
- Perfect for cross-connect in high-density ports.



Reverse HDX Cassettes

- Assembled with optical fibers of the SM or OM4, female MPO / MTP connector (without guiding pin) with type B polarity at the back part and front connectors and adaptors of the type LC;
- Ports presented in reverse order – from left to right, the cassette presents ports from 1 to 6;
- Simple insertion in the products it applies to, with no need of special tools or mechanical adequacy.

Direct HDX Cassettes

- Assembled with optic fibers of the SM or OM4, female MPO / MTP connector (without guiding pin) with type B polarity at the back part and front connectors and adaptors of the type LC;
- Ports presented in direct order – from left to right, the cassette presents ports from 1 to 6;
- Simple insertion in the products it applies to, with no need of special tools or mechanical adequacy.

HDX Consolidation Point

- Fixing in a wire runners or under technical floor;
- Serves up to 36 fibers using pre-terminated 3 HDX cassettes, in a modular and progressive way;
- Perfect for Retrofit of existing DC with short split-level and cooling restrictions.

3.6.2 COPPER CABLING

LAN Cable GigaLan Augmented CAT.6A

- It supports 100 Mbps, 1 Gbps and 10 Gbps transmissions in channels up to 100 meters;
- Electric characteristics in high-speed transmission 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;
- External fire-retardant cover free of halogens, with low level of smoke emission (LSZH).

Pre-Terminated Shielded Cable GigaLan Augmented CAT.6A

- Cable composed of 6 solid cables CAT.6A F/UTP, 23 AWG, gathered in the trunk through a mesh made of fire-retardant and connectorized at both ends by a shielded female connector CAT.6A;
- The connectorized ends are provided with articulate Dust Cover (frontal cover) – for application of identification – and labels, which enable fast identification.

Patch Cord GigaLan Augmented CAT.6A

- Patch Cord CAT. 6A with connectors RJ-45 with double claws, which guarantee full electric connection with the copper cable and covered by metalized material, to guarantee high performance at external noise and interconnection with the grounding system at both ends;
- External fire-retardant cover free of halogens, with low level of smoke emission (LSZH).

Keystone Jack GigaLan Augmented CAT.6A

- UL or ETL LISTED Certification and ETL VERIFIED Certification;
- Contacts made of phosphorous bronze with 2.54 mm nickel and 1.27 mm gold layers.

3.6.3 COMPLEMENTARY INFRASTRUCTURE ACCESSORIES

ITMAX Rack 19” 45U

- Supplied with 2 or 4 poles, they are supplied with threaded rivet, with no use of cage nut;
- Vertical guide 200 mm, recommended for end of row purposes; and vertical guide 315 mm used between racks. They are provided with plastic fingers for better organization of the cables and with radial accommodators, protect the cables from excessive curvature.

Server Rack

- Standard rack 19” with ½U holes for fixation of equipment and accessories;
- Single reversible front door and split door at the back with 50% ventilation index – allows correct air flow with ventilated door;
- Front door and split door with retractable switch – it guarantees the equipment safety against non-authorized access.

4 METRICS, INSTALLATION AND MANAGEMENT

IN THIS TOPIC, WE PRESENT SUGGESTIONS ABOUT HOW TO CONDUCT THE IMPLEMENTATION WORKS QUICKLY AND EFFECTIVELY, EITHER OPERATIONALLY OR FINANCIALLY.

It suggested for the implementation to be organized with clear identification of the main participants, coordinated by an organizational chart during the project life – with information about the responsible for each stage of the scope and who the coordinators and the inspector will be, who will guarantee the project continuity and its final quality, respectively.

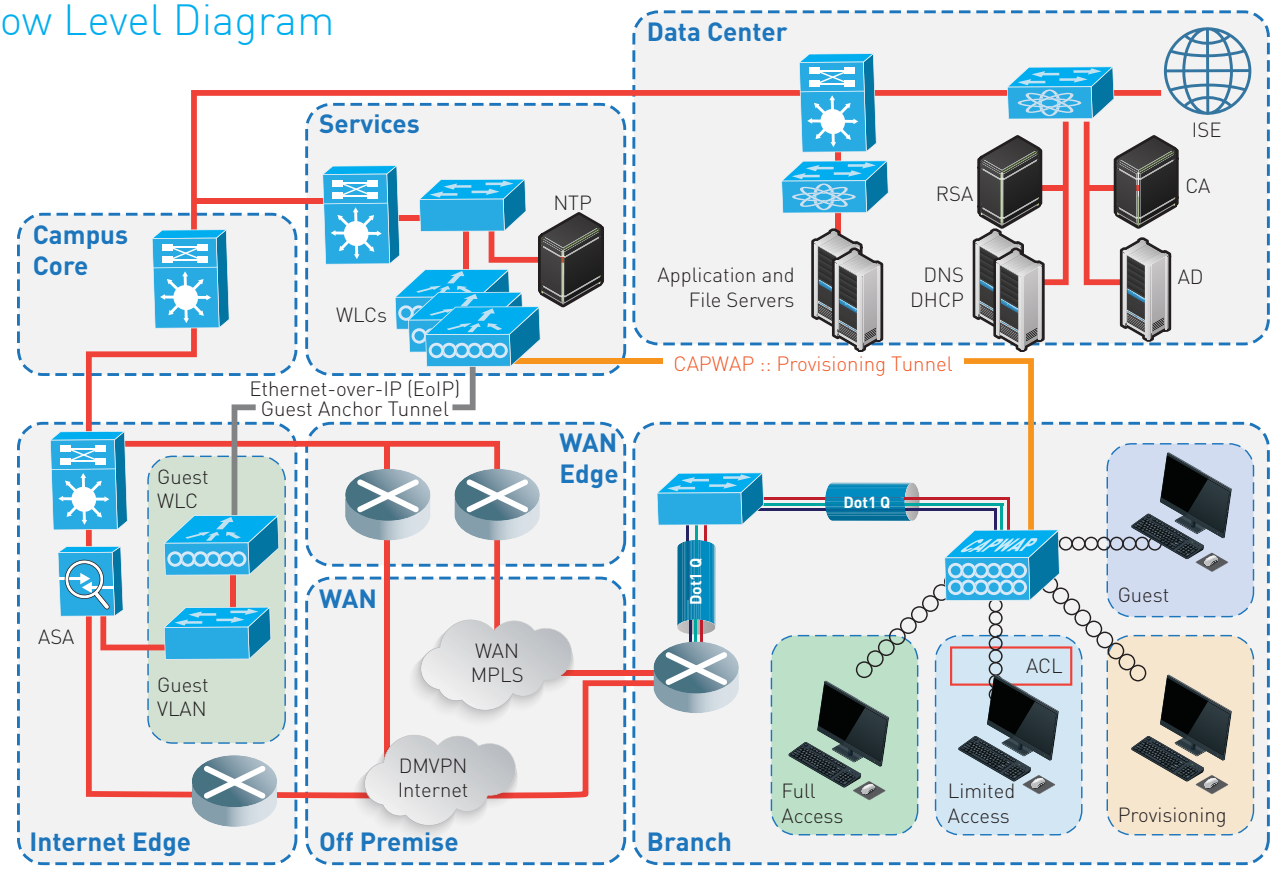
In this scenario, the **Cabling Supervisor** is an important role – a central figure of the cabling installation, who provides the bridge between the customer, the designer, the inspection and the general coordination of the works, in addition to having global vision of the cabling project and its interfaces with other competences (power, civil, air conditioning, etc.). This professional will be present all time at the work site and shall have at least the minimum qualification to manage the implementation process.

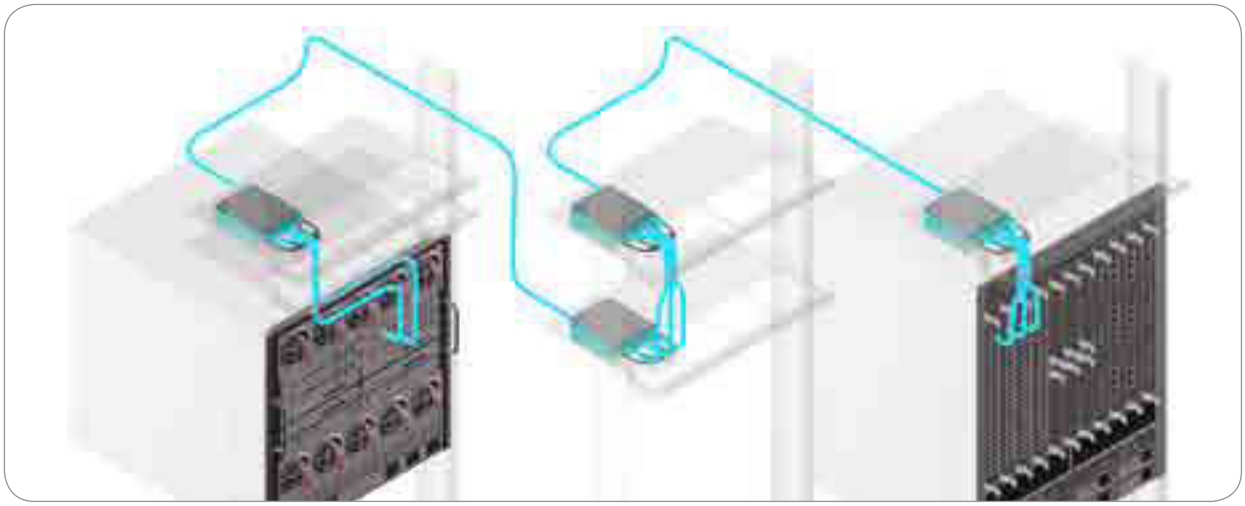
4.1 GOOD INSTALLATION PRACTICES

We recommend performing planning always before any installation, based on low level network diagrams, which can be obtained from the customer´s network team.

STANDARDS
TIA-942 / ISO11801

Low Level Diagram





From the documentation elaborated by the server, storage and network teams, the cabling infrastructure team can analyze the project, in the civil construction and architecture, electric and air conditioning projects and cabling routing infrastructure (cable runners, trays, electric ducts) checking the best form to fulfill the requested connections, building the network cabling within the standards and able to support by current and future technologies.

4.1.1 CLEANING

In highly critical environments, such as a Data Center, one connection may compromise the operation of the whole system. The optical channel depend directly on the quality of the used connectivity.

The IEC 61300-3-35 standard, used as a reference between the customer and the supplier, defines a set of quality requirements for the optical connectors faces and was conceived to guarantee the performance and good Insertion Loss and Return Loss levels.

If the problem is in a multi-fiber connection, we will have 6 affected channels.

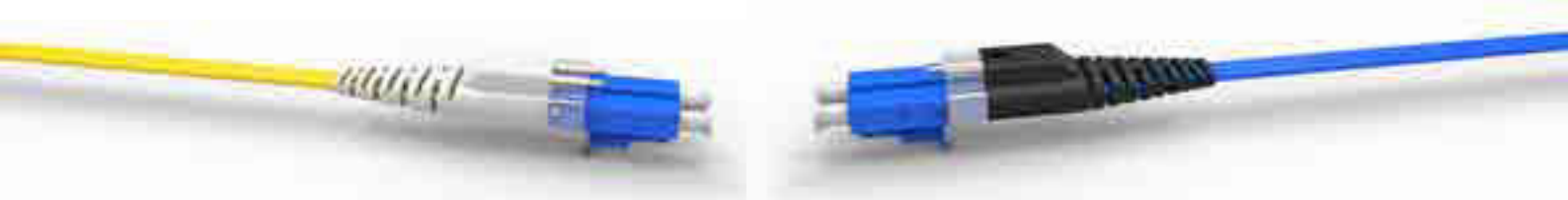
Standards for 40/100 G transmissions or Fibre Channel systems determine maximum loss of link, in order to guarantee perfect signal transmission.

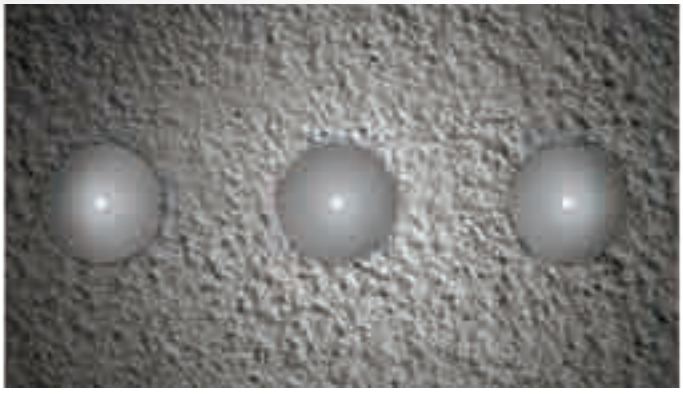
Both models require basically 3 factors for an excellent optic connection: Alignment of the fiber cores, physical contact between the connectors and the ferrule interface.

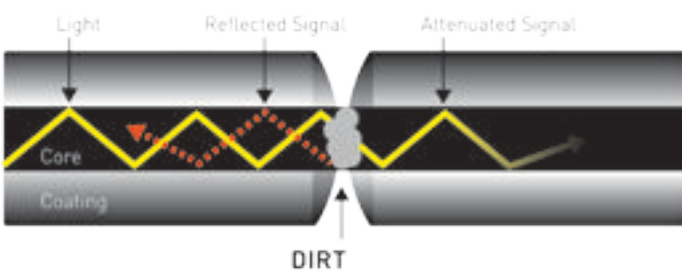
Alignment of the fiber cores and the connectors interface are mainly influenced by factors determined in production line during connectorization and polishing of the ferrule surface, associated to the use of good quality optical adapters. The production techniques existing today almost eliminate all problems related to the surface alignment and polishing.

Thus, in general, the item that will determine a poor connection will be the quality of the physical contact provided during installation. The main problem found in field is the connector cleaning before performing the connection. A single particle between the fiber cores may cause significant Insertion Losses and Return Losses and even damages to the equipment.

Some particles may cause permanent damages to the ferrule surface. In general, the problem is detected after it has already been caused. However, prevention is quite simple and can be done quickly, cleaning the ferrules before each connection.

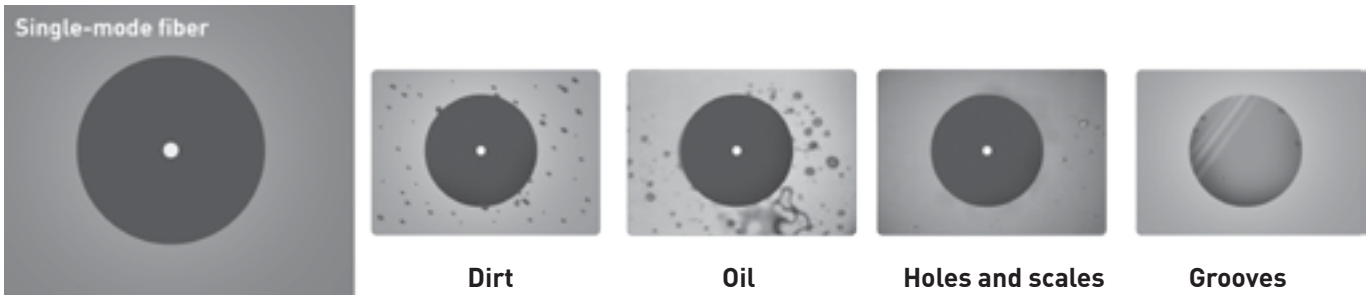






Dirt

Common types of contamination and defects include the following:



Dirt **Oil** **Holes and scales** **Grooves**

Contaminating agents can be found in any place during installation and activation of an optic network: in the air, hands, clothes, adapters, latch protectors, test equipment, etc.

The average size of the dust particles is 2-5 µm, which is not visible for the human eye and a single grain of dust can be a big problem, when incorporated on or close to the fiber core. It is important to point out that even a new connector can be dirty, thus, before any connection, it is necessary to clean the optic elements.

The cleaning of the optic elements can be carried out by means of different tools or by means of special tissues adequate for this purpose.

- **DRY**: using adequate tools available on the market.
- **WET**: using adequate tools and isopropyl alcohol.

35300008
Cleaning tool LC

35300007
Cleaning tool – SC/FC/ST/E2000

35300029
Cleaning tool MPO

Paper tissue – without lint release

Cleaning liquid FCC2

4.1.2 CABLE LAYING

Recommendations for the cabling installation activities:

- Executive project available at the site;
- Understand the project, which will be executed, regarding the solution, which will be applied;
- Material check-list – whether it is according to the specified in the project;
- Inspection at the site:
  - Identify the critical points (probable sources of interference) and take preventive action, informing the designer or the responsible for the works to apply the adequate solution;
  - Telecom Room: check for sources of humidity, whether there are no chemical products or storage of materials, which are not used in the intended activity;
  - Infrastructure: whether it is according to the project, with finishing, grounding connection, dimensioning of electric trays and ducts;
  - The network lenght: check whether it does not exceed 90.0 m horizontal cabling;
  - The existence of external environment points;
  - The existence of aggressive environments or environments with moisture;
  - Proximity with electromagnetic power sources.

4.1.3 ACCOMMODATION

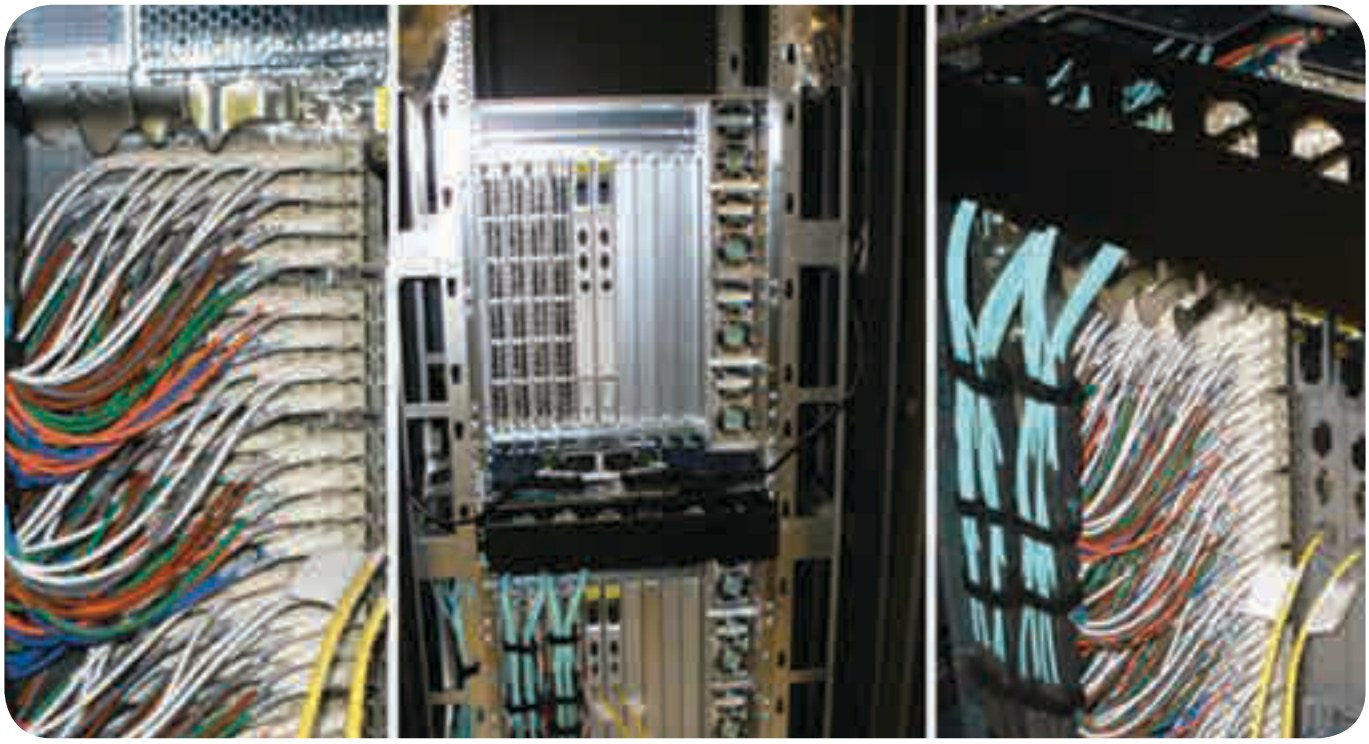
We recommend observing the accommodation of the cables in the infrastructure, based on the type of cable installed and its exit order – from the infrastructure to racks, consolidation points or another infrastructure (perpendicular, vertical or electric tray to electric duct).

It is important to record in the project the constant use of all infrastructure accessories for the perfect accommodation and preservation of the cables during launching, such as, elbows with adequate curvature angles, connection accessories, termination and derivation.

4.1.4 ORGANIZATION

The main issue of the cable organization currently are the high-density racks. When the maneuver area is duly organized, all high-performance electronic and optical characteristics of the channels are kept.

We recommend the use of our complete lines of accessories and horizontal and vertical guides, in addition to components, which help the installer to organize the cabling on the rack.



4.2 NETWORK CERTIFICATION

The network certification serves to guarantee, by means of documentation, that the structured cabling performance parameters are in compliance with the standard in force selected as a base of the project.

In addition to the test report for all certified items, other advantages can be obtained with the certification:

- All applicable local and international standards have been complied with;
- All good project and installation practices of the manufacturer have been followed;
- All materials used are manufactured by the selected supplier;
- The materials have not been smuggled or falsified;
- The contracted integrator is recognized by the manufacturer and his/her training is up-to-date.

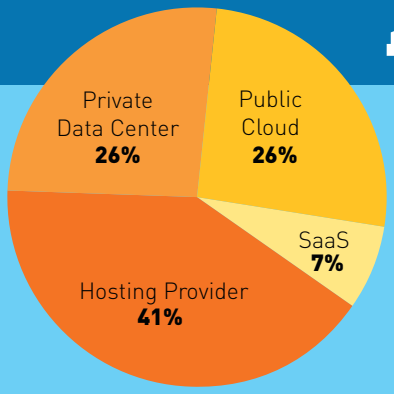
Rework already installed cabling is very expensive. Remain without the network functioning is even more expensive.

- 70% of the network problems are due to cabling (Real Decisions Institute);
- 80% of the companies' business depend on the network (Gartner Group);
- 40% of the IT managers' time is spent for problem solutions (Computerworld).

Industry	Downtime cost per hour (US$)
Brokerage Operations	6,450,000
Energy	2,817,846
Credit Card Sales Authorization	2,600,000
Telecommunications	2,066,245
Manufacturing	1,610,654
Financial Institutions	1,495,134
Information Technology	1,344,461
Insurance	1,202,444
Retail	1,107,274
Pharmaceuticals	1,082,252
Banking	996,802
Food/Beverage Processing	804,192
Consumer Products	785,719
Chemicals	704,101
Transportation	668,586
Utilities	643,250
Healthcare	636,030
Metals/Natural Resources	580,588
Professional Services	532,510
Electronics	477,366
Construction and Engineering	389,601
Media	340,432
Hospitality and Travel	330,654
Pay-per-View TV	150,000
Home Shopping TV	113,000
Catalog Sales	90,000
Airline Reservations	90,000
Tele-Ticket Sales	69,000
Package Shipping	28,000
ATM Fees	14,500
Average	**944,395**

Outages Happen: Cloud Hosted On-premise 2012

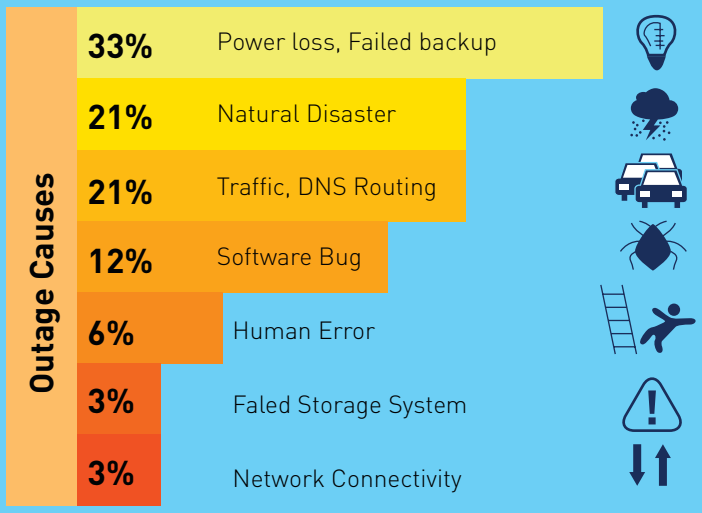
27 notable publicly reported outages worldwide.



Mind the Weather Guy

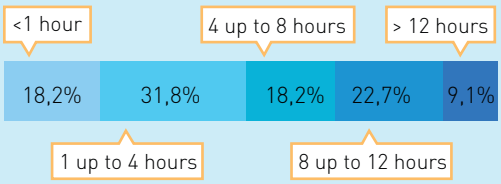
Hurricane Sandy caused 6 of the outages

What went wrong?



Time out

Outage length
Data based on 22 reported outages



Doctor, do we have a pulse?

Average MTTR
(mean time to recovery)
7.5 hrs

Are you prepared?

The average company with a data center experiences **1 large scale outage** and **3 partil outages** per year.

Sources: RightScale, Amazon, Data Center Knowledge, eWeek, Forbes, GigaOm, Google, Microsoft, Twitter, Uptime Institute.

4.2.1 TESTS IN OPTICAL CHANNELS

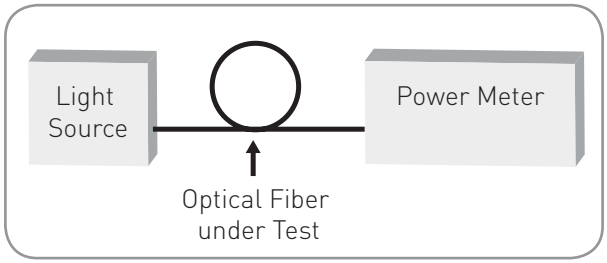
The measurements of optical channels can be:

- Laboratory – "Component level".
- Field

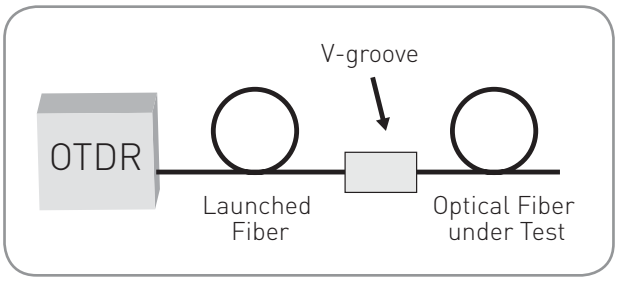
Basically, two equipment units are used for optic measurements:

- POWER METER.
- OTDR (Optical Time Domain Reflectometry).

POWER METER – Indicated for LAN's



OTDR – Indicated for long lengths (CATV / TELES)



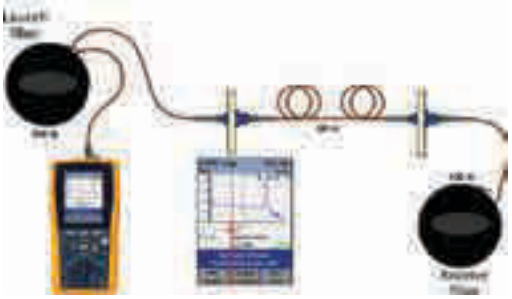
- Check the use manual of the equipment manufacturer.
- Follow the calibration and measurement recommendations.
- Not calibrated equipment **cannot** be used for Extended Warranty.

Test Report

- DTX Standard (Power Meter).
  - It presents the attenuation parameters in both windows;
  - Graphs are optional – they facilitate the visualization of the margin proposed by the manufacturer;
  - Attenuation results are obligatory.
- OTDR Standard.
  - It presents the attenuation parameters in both windows;
  - Graphs are obligatory – they allow the visualization of the events, which have caused attenuation and their position on the cable – approximate distance of the source of light;
  - Attenuation results are also obligatory.

Tests Methodologies

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

Standard	Method	
TIA	TIA-568-C	
	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 
Common item (obligatory)	Field polarity test with VFL	Field polarity test with VFL

For optic channel tests in critical mission environments – Data Center, Furukawa evaluates the optic system polarity, in addition to the executive project of the optical link system and all installation and assembly conditions and the technical certification of the project and installation team, as a way to certify the functionality of the optical network and its performance response according to attenuation parameters x application, in order to consider extended warranty contracts. Thus, both test levels are necessary.

Performance Test Parameters

For this analysis, the parameters of the ISO/IEC standard are adopted. They are also in compliance with the ANSI/TIA standards:

- ISO / IEC 11801 stipulates the single performance parameter for field test of the optic fiber links as link attenuation (alternative and equivalent period: loss of insertion) for installation of components compatible with this standard.
- For the mentioned example, the link for attenuation shall be calculated according to the specifications within ISO / IEC 11801. These specifications are obtained from the following formulas:

Link attenuation = Cable attenuation + Connector Attenuation + Splice Attenuation

Cable attenuation (dB) = Cable Attenuation Coefficient (dB/km) x Link Length (km)

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

Optical Fiber	Wavelength (nm) / Attenuation Coefficient (dB/km)			
Multimode 62.5/125 µm	850	3.5	1300	1.5
Multimode 50/125 µm	850	3.5	1300	1.5
Single-mode	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
- Splice Attenuation (dB) = Number of Splices x Attenuation per Splice (dB)
- Maximum Attenuation Provision per Splice = 0.3 dB

NOTE: the link attenuation does not include active devices or passive devices, which are not the cable, connectors and splices, i.e., the link attenuation does not include devices, such as, optical splitters, couplers, optical repeaters or amplifiers.

The attenuation limit tests are based on the use of the Reference Method 'One jumper' specified by Method 1 of IEC 61280-4-1 for multimode fibers and Method 1 of the EN61280-4-2 standard for single-mode fibers or another equivalent method to be defined in the Optic SCE project. The user shall follow the procedures established by these standards or application notes to carry the performance tests precisely.

- **Horizontal MM (multimode) Link:** acceptable attenuation link for horizontal multimode optical fiber cable system is based on maximum distance of 90 m. The horizontal link shall be tested at 850 nm and 1300 nm in one direction, according to method 1 of IEC 61280-4-1, with a reference jumper.
- **The Backbone MM (multimode)** link shall be tested in one direction and in both operation wavelengths to manage the attenuation variances associated with the wavelength.
- **Backbone MM (multimode) Links** shall be tested at 850 nm and 1300 nm, according to method 1 of IEC 61280-4-1. This shall be done because the backbone length and the potential number of splices vary according to the condition of the location, the link attenuation equation (Section 2.2) shall be used to determine the limit values (acceptance).
- **Backbone SM (single-mode) Links** shall be tested at 1310 nm and 1550 nm, according to the IEC 61280-4-2 standard, applying the Reference Method 'One jumper' or equivalent method. All links SM (single-mode) shall be certified with the testing tools, using laser light sources at 1310 nm and 1550 nm (see note below).

NOTE: links to be used with network applications, which use laser light sources (underfilled launching conditions) shall be tested using test equipment based on laser light sources categorized by the Coupled Power Ratio (CPR) in category 2, underfilled, by IEC 60825-2. This rule shall be followed for cabling systems to support Gigabit Ethernet, which specifies only laser light sources. Field test equipment based on LED (Light Emitting Diode) light sources is category 1 device according to IEC 60825-2, which normally produces results with high attenuation and thus, they are not recommended and tests carried out with these sources are not accepted.

- **Optional Requirement:** Each connection with optical fiber terminated with optical adapter system, which does not impose a transmission direction, shall be tested in both directions, once the signal transmission direction cannot be foreseen at the time of installation.

Certification Test Result Documentation

The test result records for each link shall be saved in the field test equipment memory after the conclusion, with the same identifier as the optical link or the analyzed optical fiber, in sequence or not; however, in inviolable way.

The test results recorded by the test equipment shall be transferred to Windows™ – database utilitarian with a base that enables maintenance, inspection and filing of such test records. It shall be guaranteed that these results are transferred to the PC unaltered, i.e., "as stored in the test equipment" at the end of each test. The popular format 'csv' (comma-separated value format) does not provide adequate protection and will not be acceptable.

The database for the completed work shall be stored and delivered on a CD-ROM or another electronic media, and these shall include the software tools necessary to display, inspect and print any selection of test reports.

A paper copy of the test results, listing all links that have been tested, shall be supplied with the following summarized data:

- Identification of the connection according to the nomenclature convention defined in the general system and project documentation;
- The global approval / rejection of the tested link, 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 the time of the test results, which have been saved in the test equipment memory.

The details of the tests made on each optical fiber and which will be saved in the database, shall contain the following information:

- The identification of the location as specified by the final user;
- The approval/rejection of the tested link;
- The name of the standard selected to execute the stored test results;
- The type of cable and the value of the "refraction index" used for the length calculation;
- The date and the time of the test results, which have been saved in the test equipment memory;
- The name of the brand, the model and serial number of the test equipment;
- The revision of the test equipment software and the revision of the database of test standard used.

The detailing of the test to be saved in the database shall contain the following information:

- Identification of the link/fiber according to the nomenclature convention defined in the general system and project documentation;
- The attenuation measured at each wavelength, the test limit calculated for the corresponding wavelength and margin length (difference between the measured attenuation and the test limit value);
- The link length shall be informed for each optical fiber, where the test limit has been calculated.

4.2.2 TESTS IN COPPER CHANNELS

Before starting the procedure for testing and certification of the structured cabling system in a site, check:

- Equipment calibrated with the due valid certificate of calibration;
- Equipment thermally stabilized (switched on at least 6 minutes before starting the tests);
- Equipment with the battery 100% loaded;
- Carry out a test on the certification equipment before starting;
- Calibrate, in field, when the equipment requires this prior procedure;
- Use the adequate pointers and heads with the application;
- Check the state of preservation of the test patch cords for permanent link certification before starting the tests;
- Attention to the environmental conditions: 0 ºC to +40 ºC and 10% to 80% humidity;
- Observe that the cabling shall be totally disconnected from active network equipment.

Certifier Software

Example: **Linkware 9.2**

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

Tips:

- Check the use manual of the Scanner manufacturer;
- Follow the calibration and measurement recommendations;
- Not calibrated equipment cannot be used for Extended Warranty.

4.2.3 EXTENDED WARRANTY

The quality of the components of a communication network infrastructure is obligatory characteristic, not optional. Together with its installation and distribution channels, Furukawa offers its **Extended Warranty Program**, which assures the performance of the installed network for up to 25 years.

The Program guarantees that the three parts involved in the process deliver a quality network, which assures the functioning of the different applications and equipment with high availability rate for a long period of time, optimizing the investment.

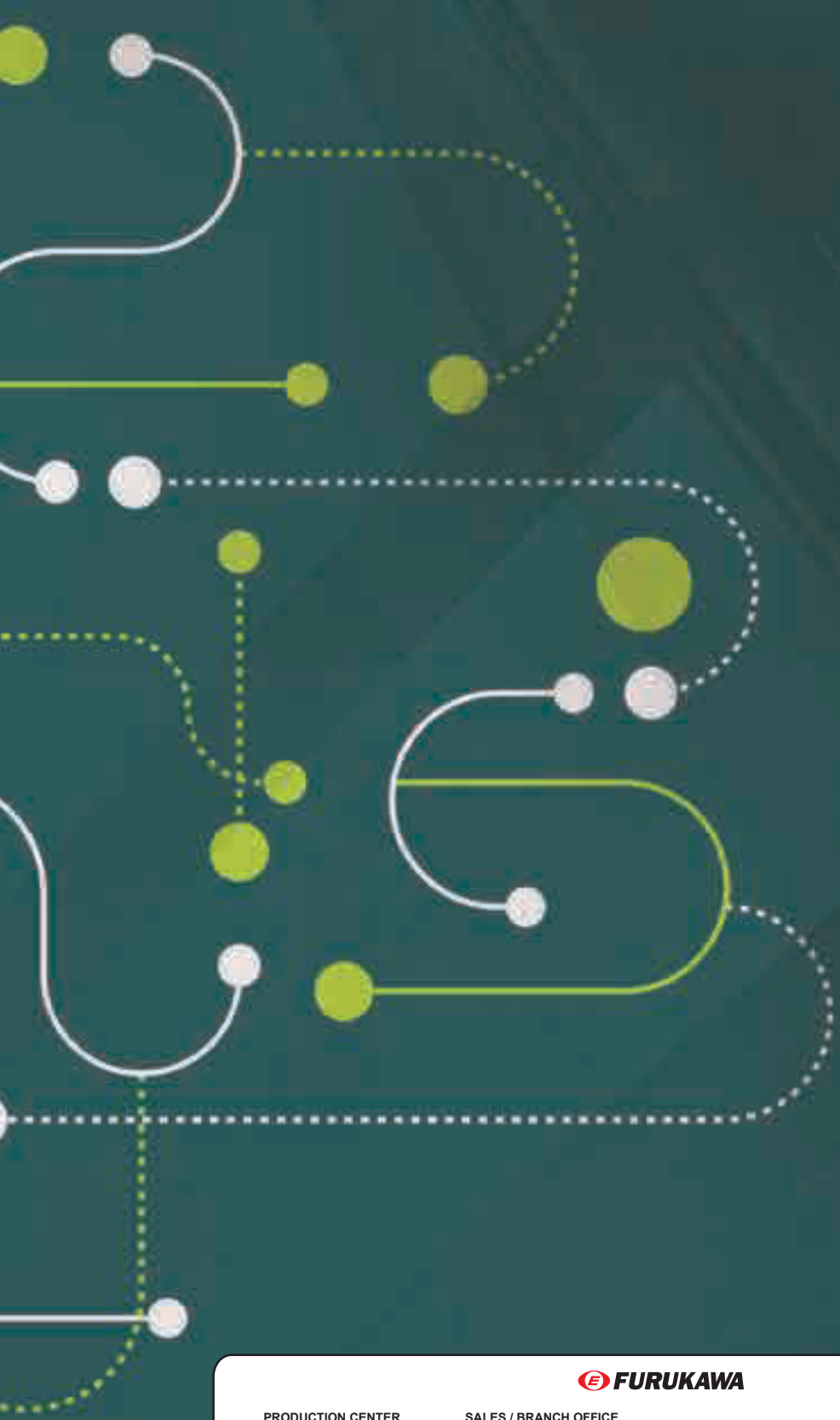
To request the Extended Warranty, the final customer shall demand it to the Furukawa Solution Provider (FSP) of its preference, which will start the process at Furukawa. There is no additional cost for this process, which aggregates the following advantages to the customer:

- Higher performance, assured by complete network certification;
- Reduction of the time for response to modifications or expansions – the cabling with Extended Warranty has better identification of the whole Infrastructure, which facilitates the localization of a network point, a backbone link, a rack, etc;
- Validation by a third party – assures that the installed infrastructure solution complies with the requirements of the network applications, such as 100 Mbps, 1 Gbps, 10 Gbps, 40 Gbps or 100 Gbps;
- Preventive claim risk analysis – checks the correct use of cables adequate to the application, including the flammability class;
- Expansion of the network service availability – checks curvature radius and/or excess of stress on cables and connectors, avoiding disconnection due to fatigue or excess of traction or compression;
- Technical and As-Built records guaranteed, which facilitates future expansion;
- A more reliable network, guaranteed for up to 25 years.

The warranty enters into force as of the issuance of the **Extended Warranty Certificate**, which is granted upon approval of the presented documentation and inspection of the works carried out by Furukawa or an authorized company.

After the process conclusion, the generated records are filed and available for the customer and the integrator.

Further clarifications can be obtained through the Furukawa channels.



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