Structured cabling in data centers

Basics, benefits and concepts

White Paper

HUBER+SUHNER

Save space and time with structured cabling in data centers

Your data center needs to be stable, secure and space-efficient. With structured cabling solutions in your data center, you will benefit from faster set-ups, easier scaling and reduced maintenance needs.

And this is why:

- **Reduce installation time with a unified approach**
- **Find the the right connector and cable faster utilising consistent labelling and marking**
- **Be ready for future expansion by creating upgrade paths**
- **Enable rapid changes due to a unified basic link design**
- **Increase airflow, fire safety and space efficiency by using trunk cables**
- **Make responsibilities transparent with clear demarcation points**
- **Reduce the risk of downtime during service adds and changes**

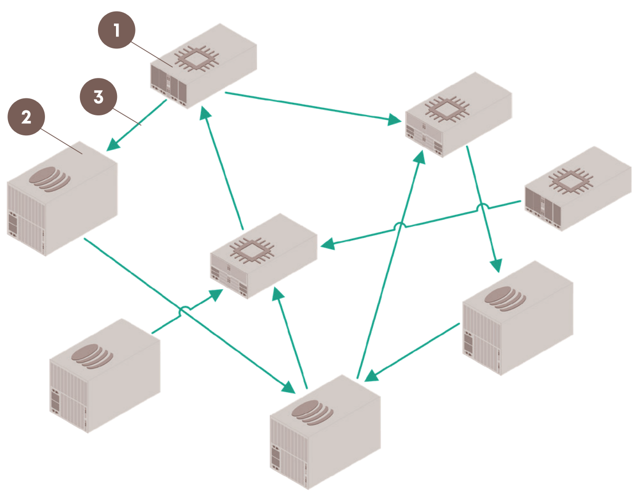
Content

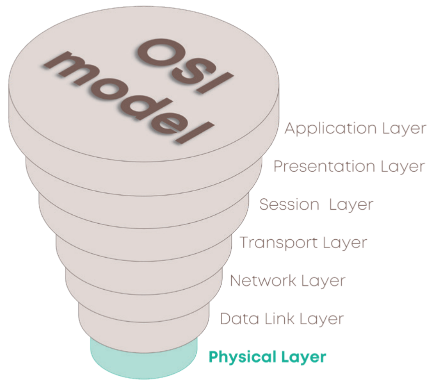
Introduction

What is structured cabling?

Physical and virtual connections in a data center

Every item of computer equipment in a data center, like a **server (1)** or a **storage drive (2)** needs to be able to communicate with each other while allowing user access from any outside location. As it is economically impossible to physically connect all equipment to all users, many **physical and virtual connections (3)** are needed both within the data center and linking it to the outside world. According to the OSI framework, communication is established on different layers and structured cabling, described in this paper, is found in the foundation of the OSI model and belongs to layer 1 – the physical layer. Structured cabling also provides the possibility to create virtual connections between equipment on other layers, however, the physical layer will be the focus of this paper.

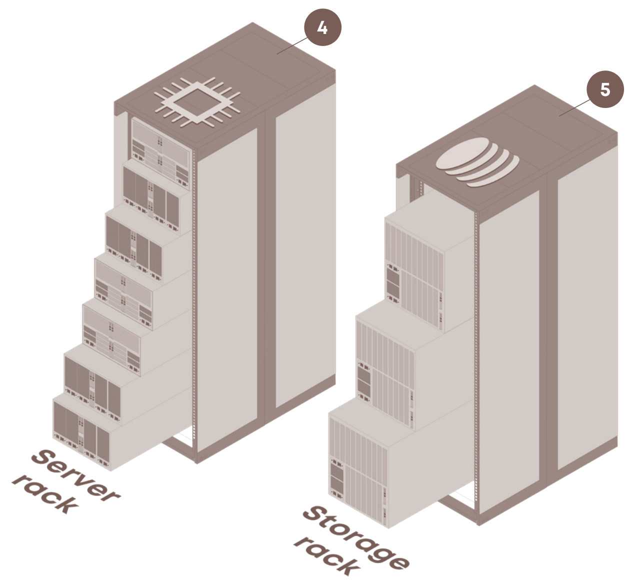




Server and storage racks

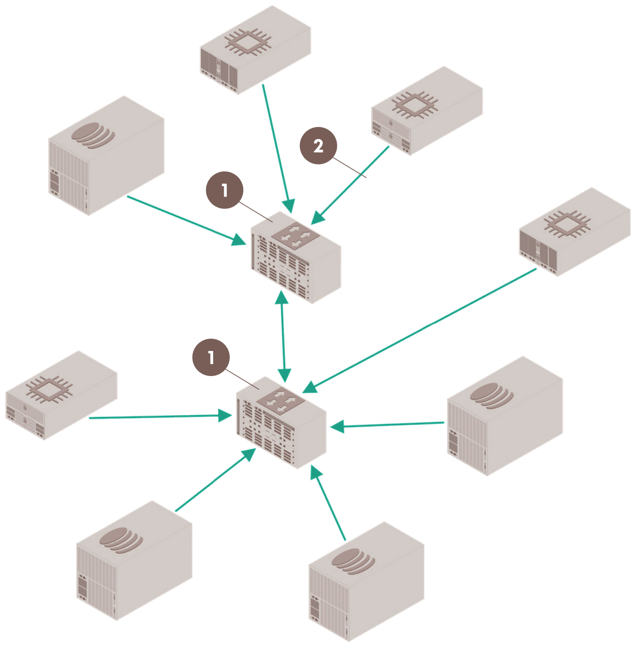
Server racks (4) need to be connected to other server racks in order to exchange data. **Storage racks (5)** are used to store data in safe and specific areas of a data center. Storage racks can consist of a variety of computer equipment which can store data, such as SSDs, HDDs and tape libaries.

There are many other types of computer equipment in a data center, including disc arrays, mainframes, supercomputers and more. However their function is not specifically addressed in this paper. For example, a physical server can also support multiple virtual servers operating on it. However, that is not relevant for an explanation about structured cabling.



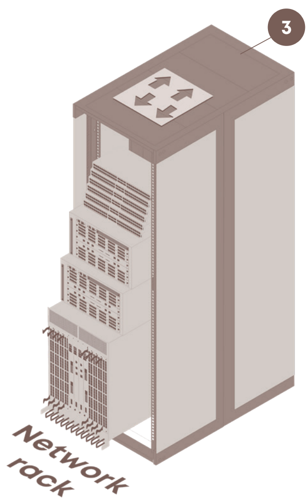
Switches in a data center

Switches (1) are another type of device which consolidate multiple data signals from computer equipment, which can read transferred data, consolidate, filter and re-direct traffic. **Main connections** (2) inside the data center are done between servers and switches. Switches can also differentiate aggregate signals from a cluster of servers or other adjacent switches. Some switches provide connections between servers, some between data storage units, or a mix of both. There can be a hierarchy of switches depending on the architecture of the network. Signals from one server can pass through many different switches until they reach another server.



Network racks

Network racks (3) are similar to server racks. Several different types of switches with specific functions, such as routers, load balancers, firewalls, LAN switches and SAN switches can be grouped together in network racks. Structured cabling is agnostic to the switch type and must follow certain design principles.



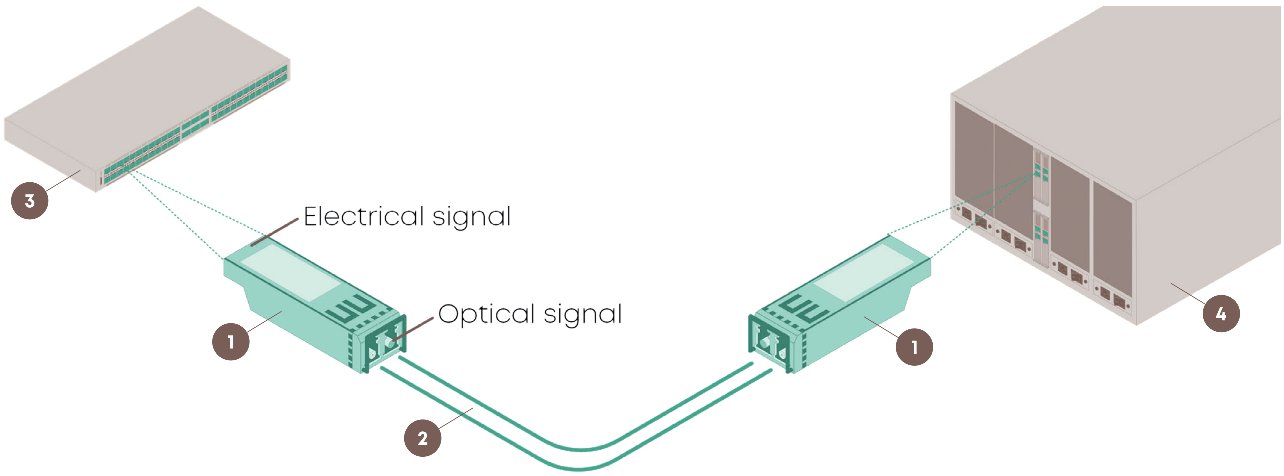
For example, in a data center there can be parallel network topologies running such as SAN and LAN. SAN and LAN aggregation equipment can be mounted in network racks at different distances. In this case, server and storage racks would require physical connections to each other. That means that from one server rack there will be two cabling set-ups: one going to the SAN network and another going to the LAN network rack.

Eventually, a server rack may be required to connect another network rack, for example, to a load balancer. Or another rack with a firewall might need to be connected to a network rack. If there is not a structured approach in place, parallel cabling set-ups like this will continue to be added over time leading to unstructured cabling.

What is structured cabling?

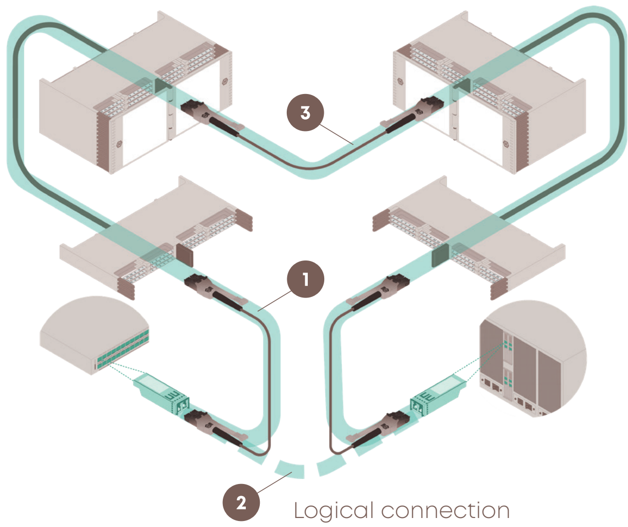
Transceivers

Within the switch there is a subunit which transmits and receives the signals from other devices – the **transceiver (1)**. A variety of transmission media can be specified to connect these transceivers. Typically in a data center it is likely to be **optical fiber (2)**. The main function of a transceiver is to convert electrical signals which can be read by processors to optical signals (pulses of lights launched into fiber) which can be transferred to another transceiver via the chosen transmission media. Every **switch (3)** or **server (4)** in the data center incorporates transceivers. An individual server typically has two transceivers while a switch may have hundreds.



Structured cabling definition

A structured cabling system (SCS) provides **physical connections (1)** of transceivers to exchange information between network and computing equipment inside the data center building and connections outside. The term "structured" describes a defined, clear and traceable design, with defined limits. It must be easy to understand by operators and support a majority of logical topologies. However, the foundation of a SCS should always be defined by a star topology. When connections to remote devices (servers, switches) are consolidated at a central point (a **distributor (2)**) it becomes easy to create **cross-connections (3)**. In reality, due to the impossibility of a single central point for all equipment in the data center, structured cabling has a tiered and hierarchical principle, so there is a distributor at every level of hierarchy. A structured cabling system design is defined in national, regional and international standards (e.g. TIA for North America, CENELEC for Europe, ISO/IEC internationally). All have relatively little difference between them, which allows for a common approach to multi-regional data center operators.



Application support

An additional benefit of the structured approach is application assurance. By ensuring all the materials, design and configuration rules are met, the transmission applications are assured to operate correctly. The rules required for transmission support are defined by standards.

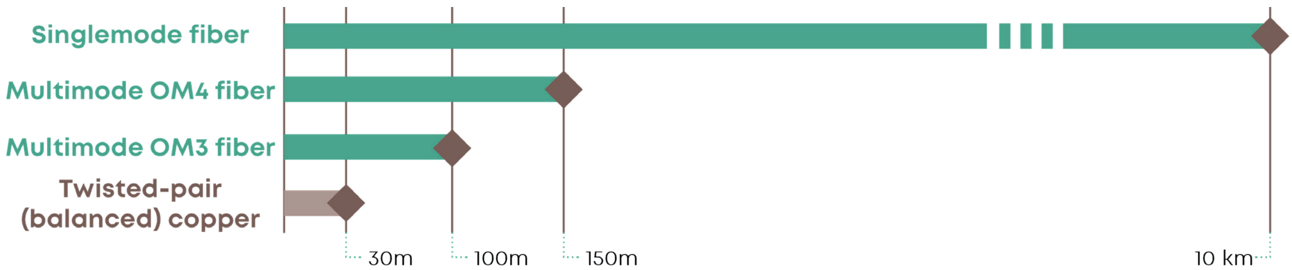
Example of networking applications and their requirements

Application	Fiber type	Channel length, maximum	Wavelength	Physical interface	Optical loss budget for cabling, dB
40GBase-SR4	OM4	150m	850	MPO-8	1.5
100GBase-SR4	OM4	100m	850	MPO-8	1.53
100GBase-SR10	OM4	150m	850	MPO-20	1.5
40GBase-LR4	OS2	10km	1310	Duplex	6.7
100GBase-ER4	OS2	30km	1310	Duplex	15
100GBase-LR4	OS2	10km	1310	Duplex	6.3
40GBase-FR	OS2	2km	1550	Duplex	4

→ Many more applications and requirements exist than the examples shown.

Copper or fiber

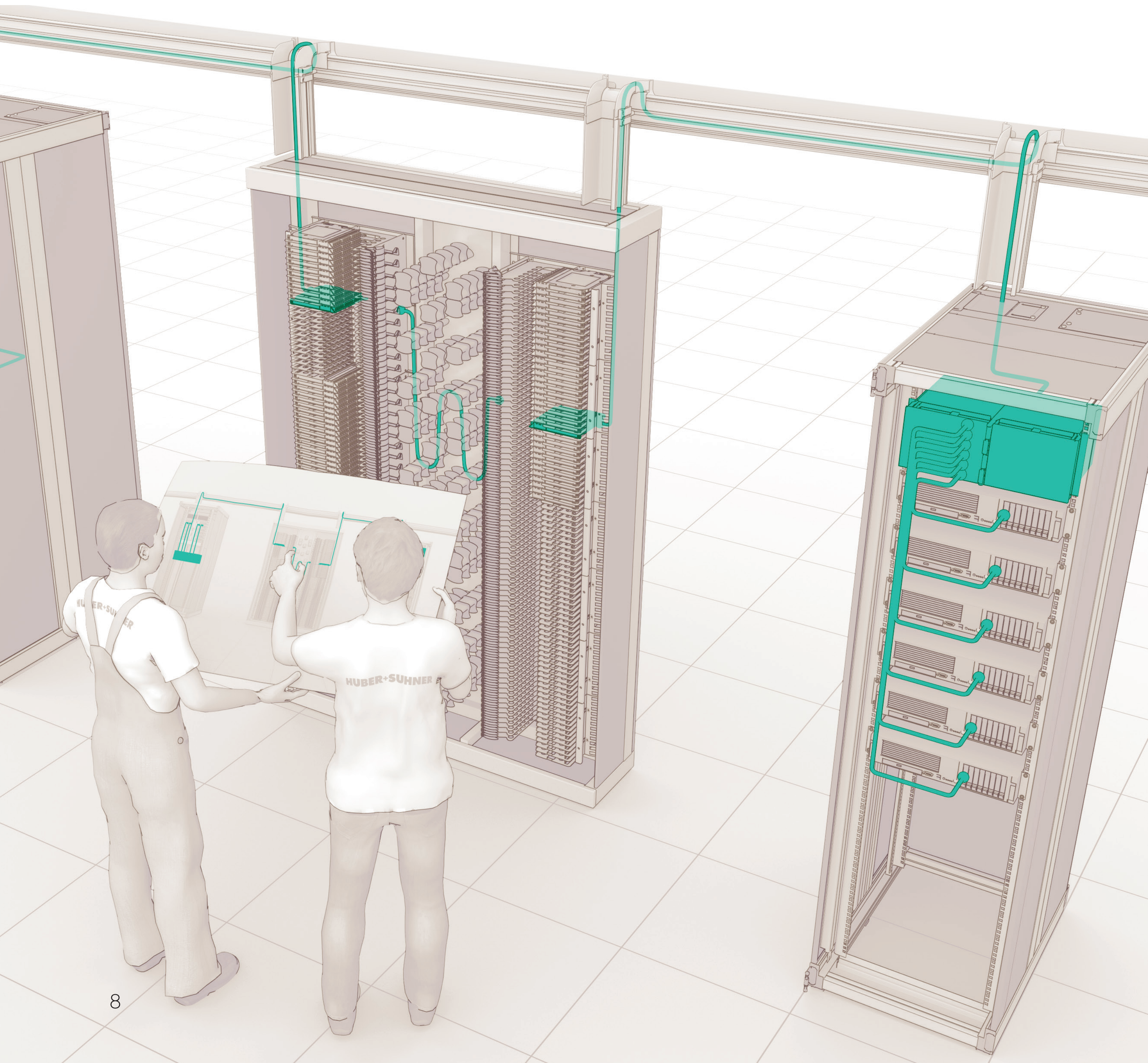
There are several options for transmission media available. The most commonly used are twisted-pair (balanced) copper and optical fiber. Optical fiber provides nearly unlimited bandwidth and has fewer distance limitations (see chart below), however some management and monitoring connections can be achieved via balanced copper. This white paper does not focus on copper connections, although it is covered by the same standards.



Benefits

Why structured cabling?

Performance and growth are at the core of leveraging a proper structured cabling approach. Without a neatly organised set-up, it is difficult to enhance the overall performance of a data center in order to scale and drive business growth.



Benefits of structured cabling

Criteria	Unstructured cabling	Structured cabling
Installation time	More time is needed to install multiple single connections between multiple locations, while repeatedly opening up floor tiles.	Save significant time with moves, adds and changes (MACs) leveraging a unified approach (adding only patch and cross-connect cords).
Traceability	Difficult and time-consuming to identify the required cable among a wide variety of other cables.	Locate appropriate connector or cable fast using proper labelling and marking that adheres to standards.
Upgradeability	Requires replacing or adding more cables due to technology change (higher speeds, different interfaces).	Existing cabling infrastructure can either be used or easily extended for future applications without the need of replacement or removal.
Rapid changes	New connections require more installation time which increases the overall time needed for network changes.	Achieve fast and easy MACs using unified basic link scenarios.
Airflow, fire safety and pathways utilisation	Point-to-point requires additional physical cabling and larger cable pathways. Over time that can clog pathways and limit the airflow requi-red to cool computer equipment. It can also negatively affect fire safety as utilising multiple small cables, leads to more plastic present which has a higher burn risk in case of a fire.	Improve fire safety and efficiency with trunk cables that provide: • greater strength (rugged durability allows for use over long distances) • compactness (multi-fiber construc-tion saves space and improves airflow) • fire safety (high-quality standards require less plastic and are specif-ically developed for use in shared pathways)
Responsibility	Hard for installation teams to define responsibilities if the network doesn't have a clear demarcation point.	Enables clear responsibilities between different installation teams with a strategic approach utilising clear demarcation points.
Downtime	Increased risk of additional MACs and installation as pathways will need to be reopened. This can cause damage or interruption to the existing connec-tions.	Reduce risk of downtime as existing cabling infrastructure remains undis-turbed for all MACs and new connec-tions.

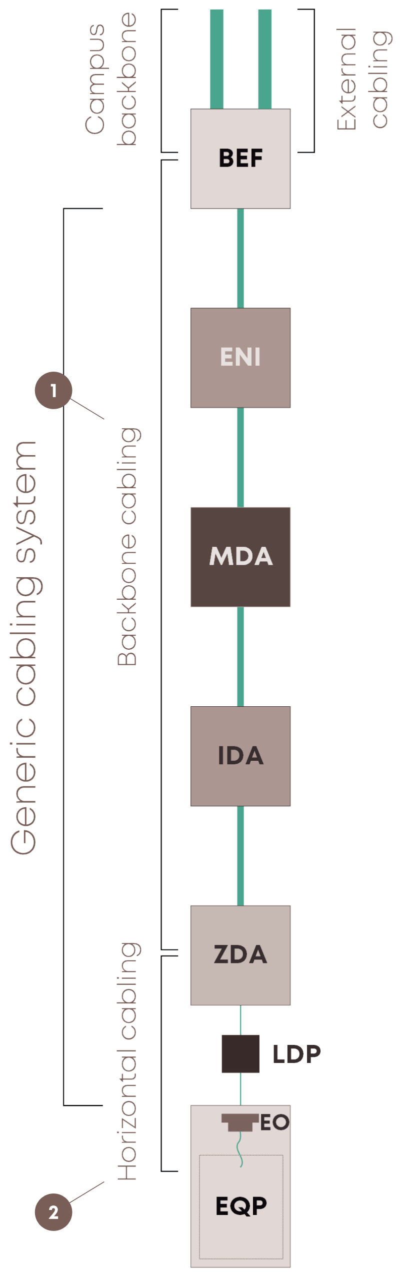
Cabling topologies

Structured cabling system principles

Structured cabling consists of two subsystems: **backbone (1)** and **horizontal (2)** cabling (or premises-specific subsystem). The term backbone (or fiber backbone, in this example) is a cabling subsystem which connects various levels of structured cabling hierarchy (different distributors) together, providing the possibility to access the outside world or any other equipment in the data center.

Occasionally, "backbone" can be termed as "vertical backbone" due to the physical layout in a multi-storey office building. In such situations, SCS backbone cables are joined to the server room with the communications rooms located on different floors. Most of these cables are located in the vertical riser between the floors.

Another type of data center cabling is horizontal or premises-specific cabling. Usually this is a subsystem which connects server racks with switch racks in data halls. This is usually a part of the lower level of the structured cabling hierarchy.



Additional information

- The backbone cabling includes everything between ENI and ZDA. Horizontal cabling includes ZDA, LDP and EO.
- Usually a backbone cabling structure is installed in the initial stages of a construction.
- Backbone cabling is often used for the whole lifecycle of a data center while the horizontal cabling part is a subject of MACs.
- Horizontal cable systems usually have a higher volume of elements which can require more space than the backbone (see 3D illustration).

Structured cabling system topology example

Standards define certain areas in the data center, termed “spaces”. Spaces are nodes in the topology connected by pathways and cabling systems.

(A) BEF – building entrance facility

(B) ENI – external network interfaces (meet-me room)

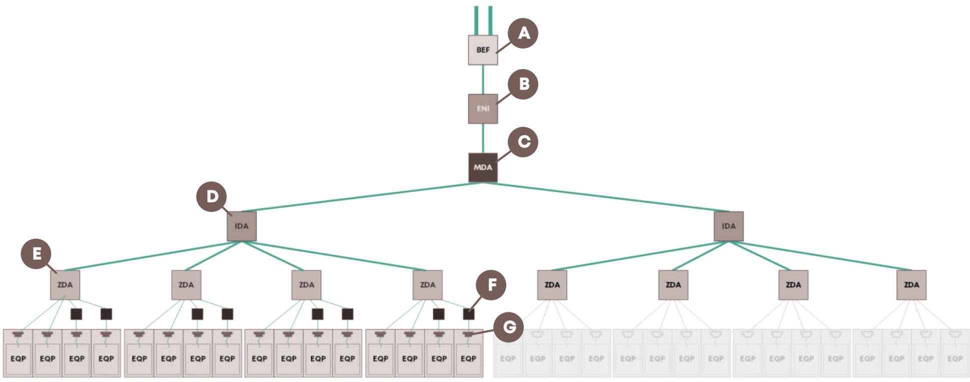
(C) MDA – main distribution area

(D) IDA – intermediate distribution area

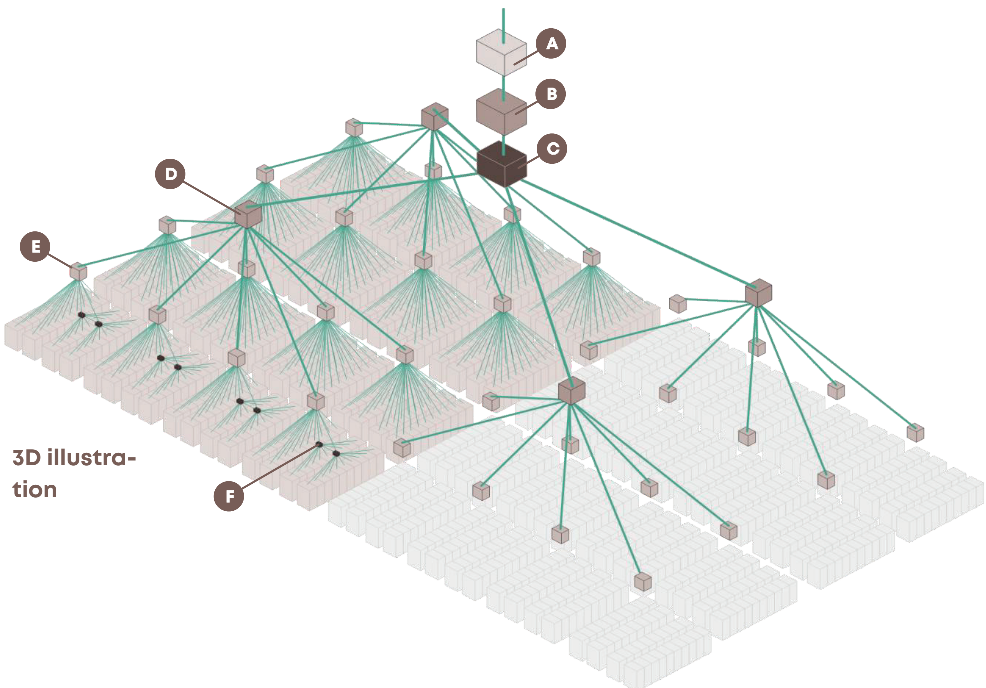
(E) ZDA – zone distribution area

(F) LDP – local distribution point

(G) EO – equipment outlet



2D illustration



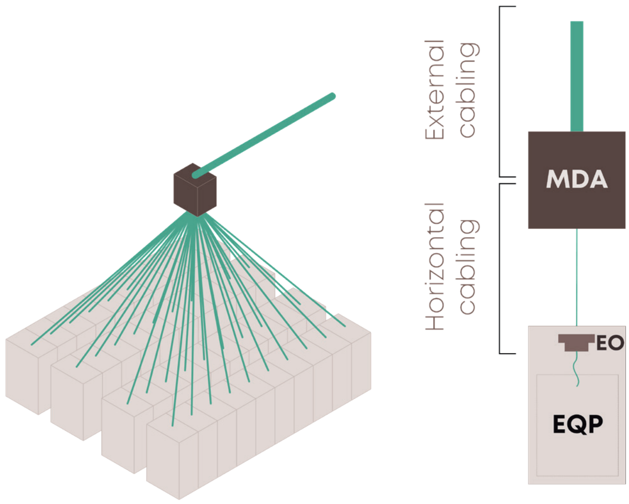
3D illustra-tion

Cabling topologies

Structured cabling system topology of a small data center

All data centers do not have or require the same topologies or hierarchies for structured cabling. The need will be determined by the scale and complexity of the facility.

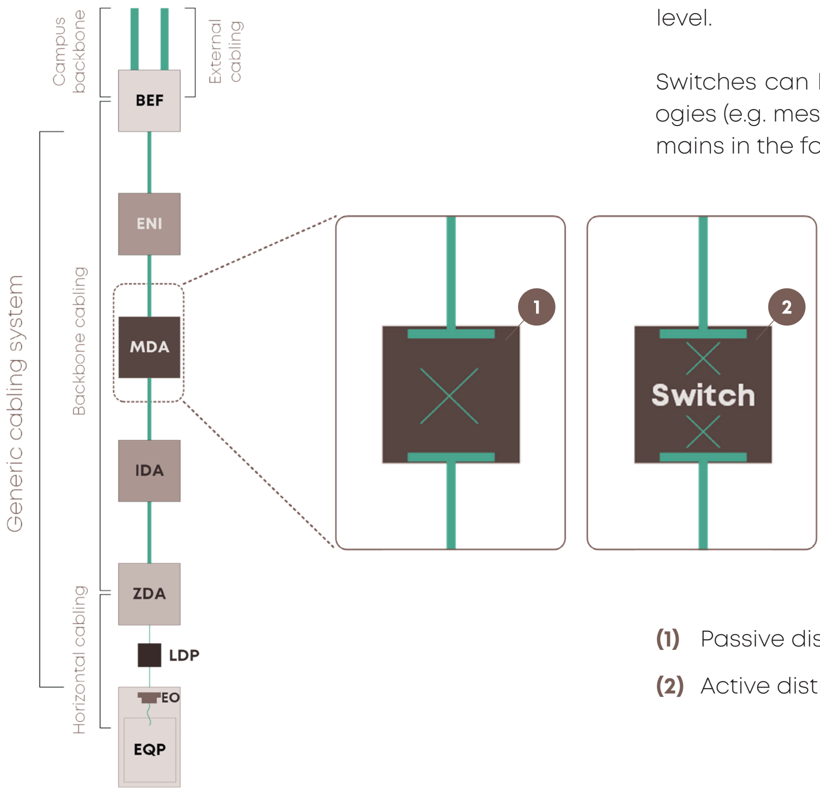
For example, smaller data centers might be constructed using only an MDA and EO, where the cabling between the MDA and EO utilises horizontal cabling. In this case, no backbone cabling is required.



Switches in the structured cabling topology

A layer of switching equipment can be located in each node of a structured cabling topology, which provides access from the lower level of hierarchy to the upper level.

Switches can be arranged via different network topologies (e.g. mesh, star, bus, ring) but cabling topology remains in the form of a star.



(1) Passive distributor with patch panel

(2) Active distributor with switch

Methods

Switch connection methods

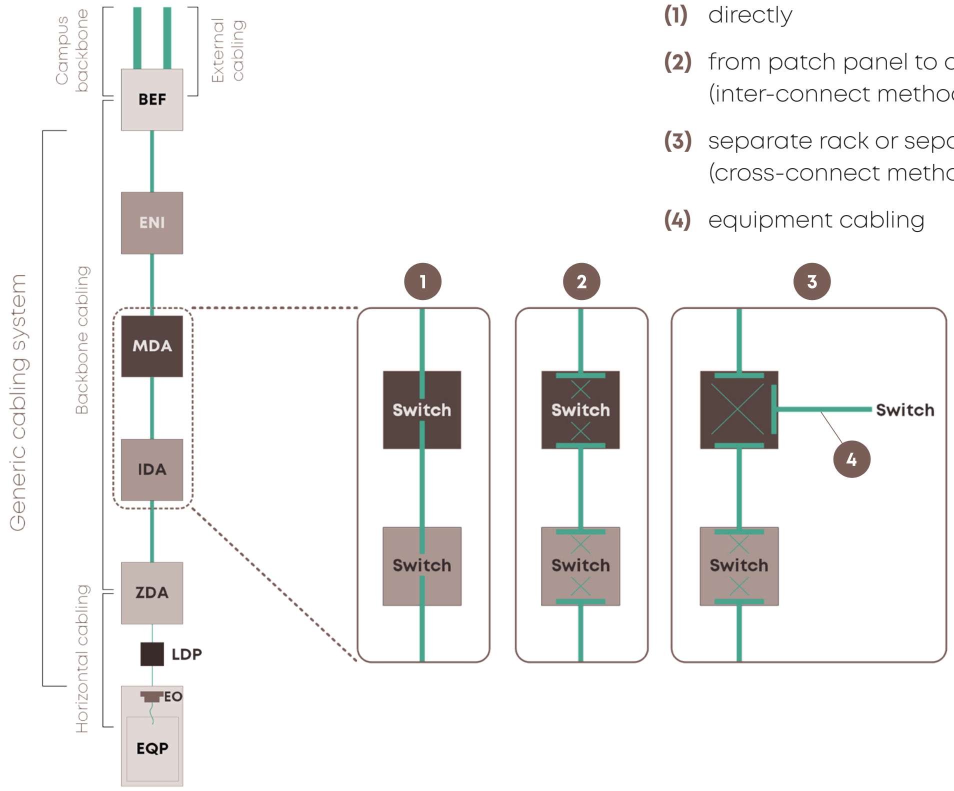
Connections between switches in nodes can be done in three ways:

(1) directly

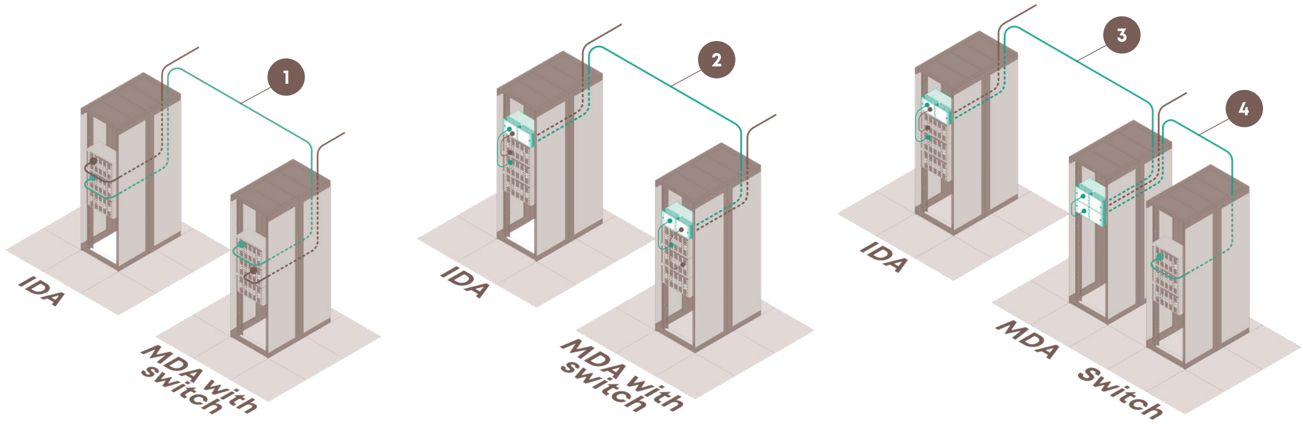
(2) from patch panel to a switch (inter-connect method)

(3) separate rack or separate patch field (cross-connect method)

(4) equipment cabling



In the cross-connect method, the cabling which connects aggregation switches with distributors (MDA) on a different hierarchy level is called **equipment cabling (4)** (or equipment cord). It can also be called port replication connections, as this cabling only replicates active equipment ports in the cross-connect rack.



Typical data center model

The model of the data center on this page demonstrates the connections between distribution levels and how they may physically look. This is a simplified model, because an actual data center may include more or less distribution areas.
This model also helps to show that different cabling-related teams are responsible for different parts of structured cabling. For example, in the colocation data center there can be four organisations' teams involved. Customers manage the cabling in the ZDA, the data center operator takes overall responsibility for the backbone cabling and connections to the ZDA. Carriers and dark fiber providers can install their cables within the meet-me room (MMR) or BEF.

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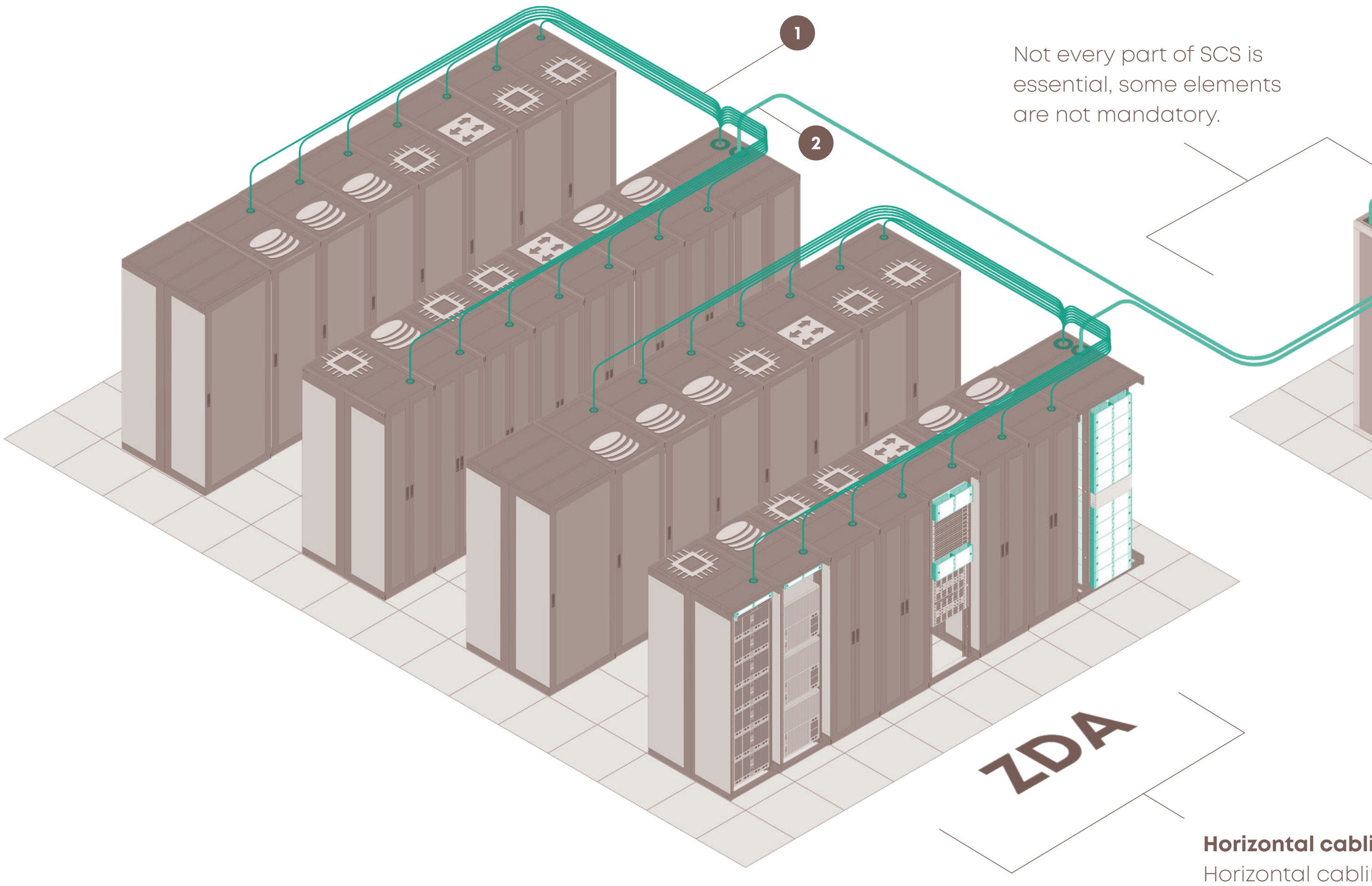

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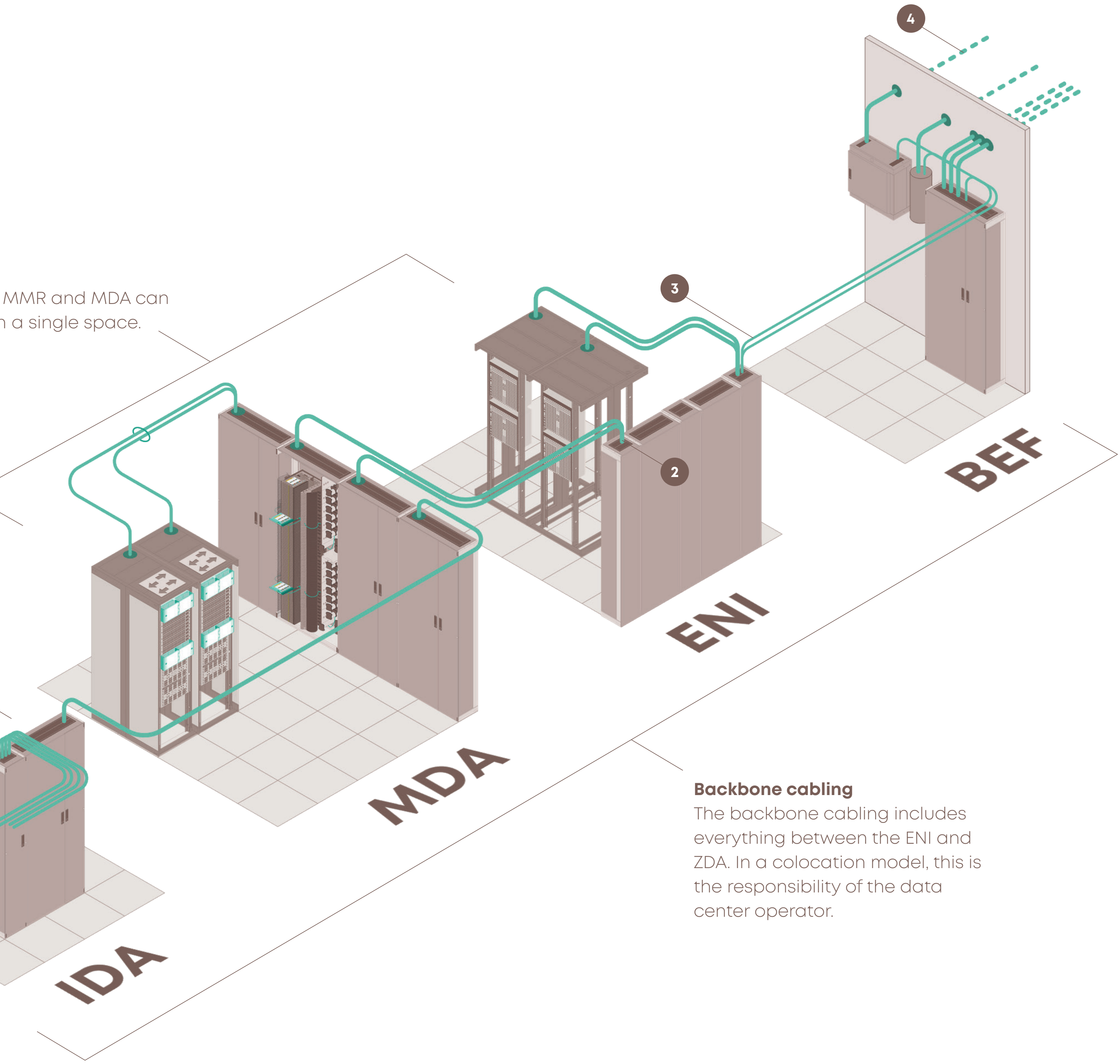

Backbone cabling
The backbone cabling includes everything between the ENI and ZDA. In a colocation model, this is the responsibility of the data center operator.

Responsibilities

(1) Customers' responsibility

(2) Data center operator's responsibility

(3) Carriers' responsibility

(4) Dark fiber providers' responsibility

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Backbone cabling explained

Connections via backbone cabling

Backbone cabling should have a clear structure from the beginning. This structure serves all installed equipment and must be maintained by the facility operator during the entire lifecycle of the data center. Maintaining this structure will prevent poor working practices, such as individual point-to-point cabling (or parallel backbones), and will give a single point of responsibility. This responsibility would mainly revolve around linking different areas within the data center.

Backbone cabling is used to connect:

(1) fiber providers, carriers or internet service providers with their customers located in data halls

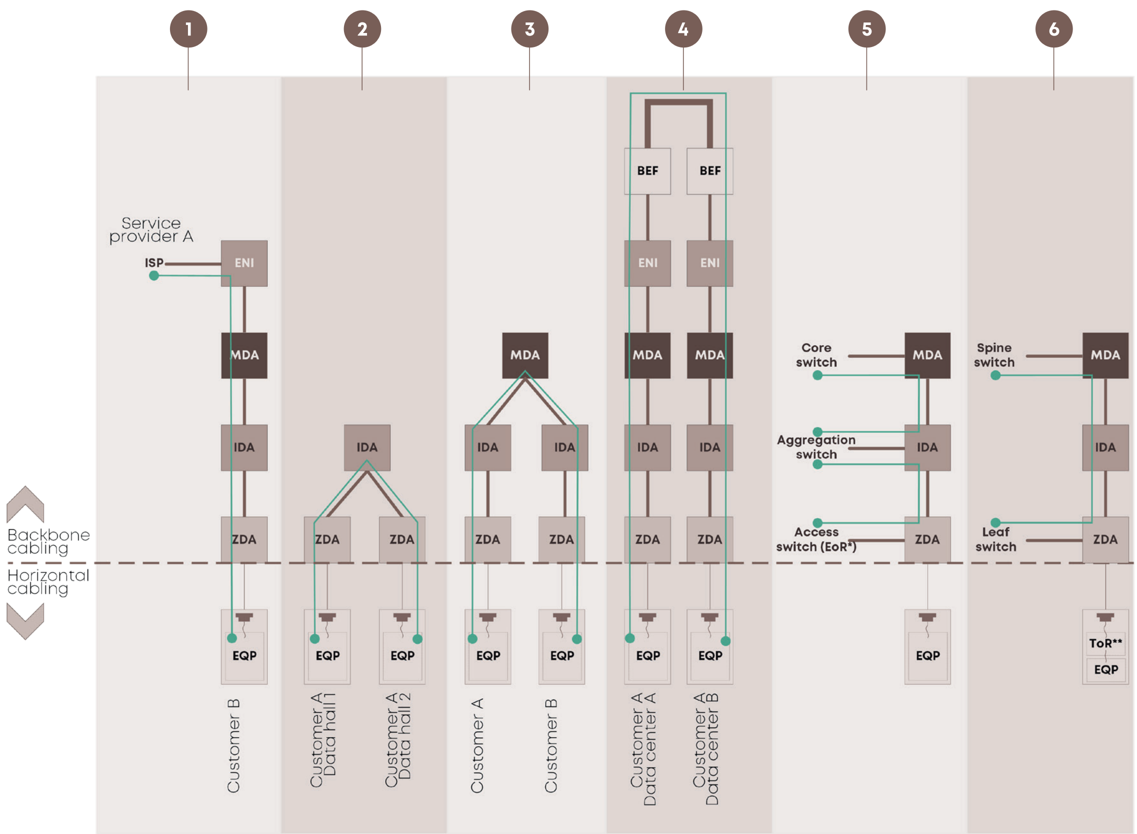
(2) equipment of one given customer where equipment is located in different data halls of the data center

(3) equipment of different customers located in different data halls to create fast direct interconnections

(4) equipment in one data center with the equipment in another data center through the external cables

(5) core network equipment on different distribution levels (core to aggregation, leaf to spine, SAN director interconnect)

(6) leaf to spine in new network topologies

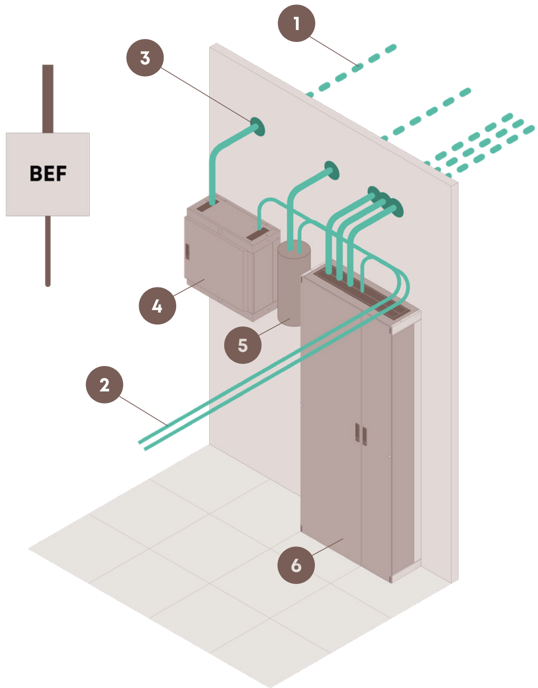


* EoR = end of row, one of network topologies in traditional network architectures

** ToR = top of rack, a switch which serves equipment installed in a single rack, used in both traditional and new network topologies

Building Entrance Facility (BEF)

Building Entrance Facility (BEF), also known as Cable Entry Point (CEP) or Building Entry Point, is a room where the transition from **outdoor cables (1)** to **indoor cables (2)** generally takes place. Usually it is a room adjacent to an external wall or just after the **physical cable entry (3)**. External cables are strong, inflexible and have jacket material that is not suitable for use within most buildings. This is because they must be fully contained within fireproof material. That is why there is a need for a location to perform the transition from outdoor to indoor cable types. This also makes cabling within the building simpler, easier and will take up less space within ducts and pathways. Access to the unmanned BEFs is usually only required when new cables need to be installed. The transition from one type of cable to another type is made in **boxes (4)**, **closures (5)** or alternatively in a **standalone rack (6)**.



The footprint of a BEF can vary depending on assumed quantity of providers. It can be very small if the data center requires relatively few providers. There can be two or more separated BEFs in a data center as providers will usually install diverse pathways for their external cable connections.

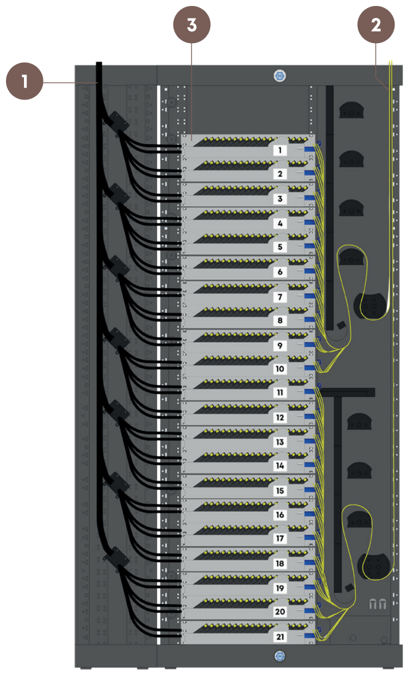
Example: Splice-through ODF 6048 in BEF

The illustration shows an example of an optical distribution frame (ODF) configured for a splice-through application supporting 6048 fibers. Outdoor multi-fiber cables are spliced to smaller individual cables, connecting BEF with multiple ENIs.

(1) 7x incoming outdoor cable 864x fiber

(2) 252x outgoing indoor cables 24x fiber

(3) 21x splice through chassis

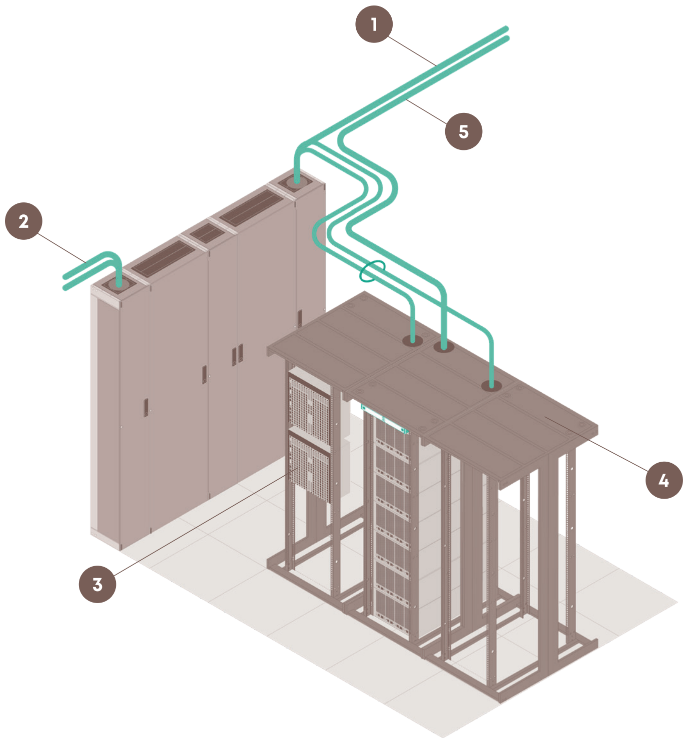


Backbone cabling explained

External Network Interfaces (ENI) or Meet-Me Room (MMR)

MMR is a commonly-used designation for ENIs. It is a room or a space where the service provider's **external cabling (1)** from the BEF meets **internal cabling (2)**. Since it's a separate space it's an ideal place for fiber or service providers to place their **equipment (3)** and connect to the data center's structured cabling. Inside the MMR there is a demarcation point where the responsibility of service providers ends and the responsibility of the data center to deliver signal to the end device starts. Access to this room is given to all service providers who house their equipment in this room. It's considered good practice to place some **empty racks (4)** into the MMR by the data center operator from the project start to allow providers to provision immediate access to the data center network.

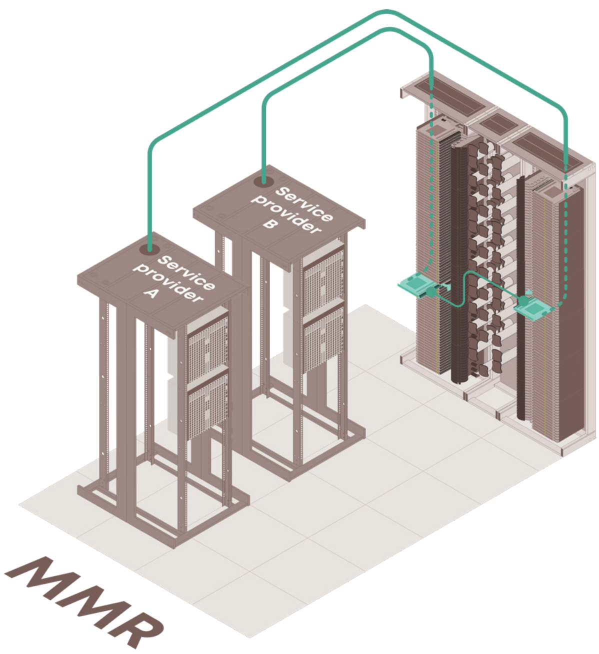
Some indoor cables from the BEF should be connected with the **service provider racks (5)** through the pathway system. Usually the MMR is relatively close to the BEF and also close to cable risers.



MMR as internet exchange point

In many cases the MMR can turn into an internet exchange point as different providers can be linked with one another.

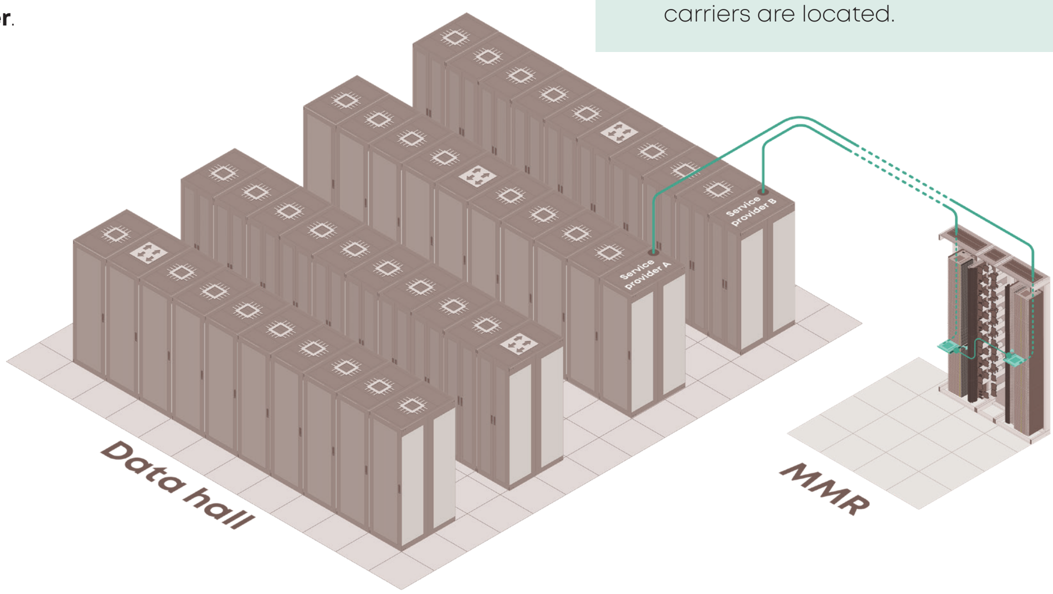
This gives an advantage to the data center operator as it multiplies the worldwide locations to which the data center is connected at high-speed. Additionally, a highly organised and neatly set-up MMR can be a positive influence for the data center operator when working with existing or potential customers.



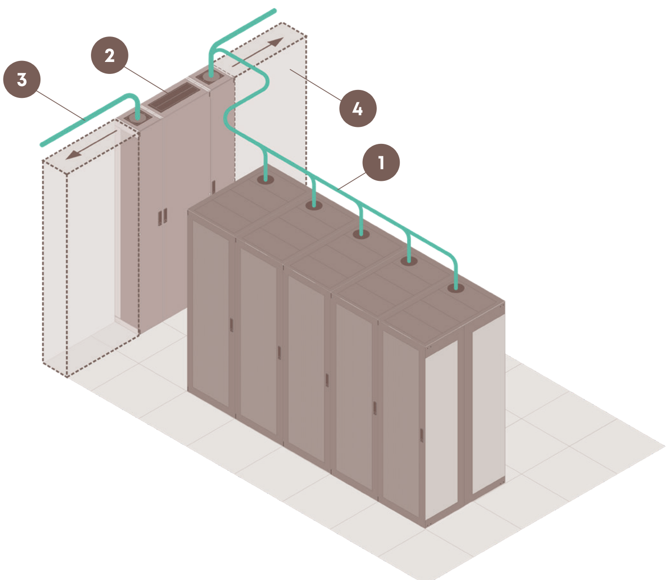
Internet data center

In the case that the MMR doesn't provide rack space, internet service providers (ISPs) can also be located in the same locations as other customers (data hall). When the data center mainly hosts service providers in a single MMR, it effectively becomes an **internet data center**.

+ This approach also allows to convert the entire data hall to the international exchange Point of Presence (PoP), where carriers are located.



MMR detail



Data center operators take general responsibility for the MMR. Ideally, the MMR should use a separate cabling system based on a cross-connect topology. This **cabling principle** (1) ideally includes cables which connect the ODF with the network or computer equipment inside the room. A dedicated **ODF** (2) in the MMR will act as the physical exchange point between different ISPs. Usually, backbone cabling connects the ODF in the MMR to the **MDA** (3).

The configuration of the ODF in the MMR and its size should be calculated carefully. Usually, one ODF is enough to accommodate all fibers at the beginning of the lifecycle of the data center, but with the growth of data traffic, new providers appear and the usage of fiber is increasing. A **space reserved** (4) to extend the ODF with more racks and cables should be considered from beginning.

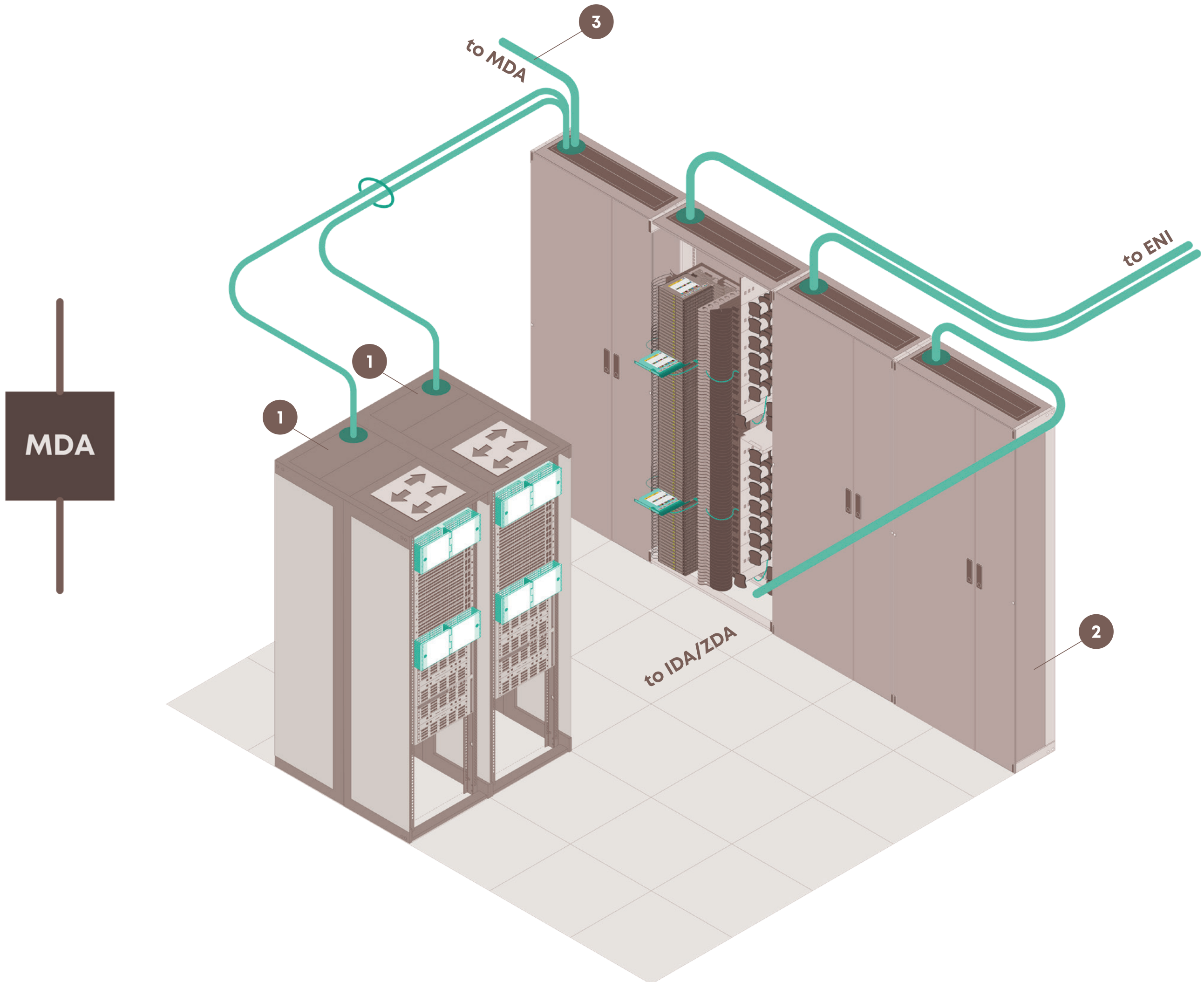
Backbone cabling explained

Main Distribution Area (MDA)

The MDA is an area or areas where **main switches (1)** and the **Main Distribution Frame (MDF) (2)** of the entire building are located. The MDF in the MDA is at the core of the structured cabling system and the central point of the star hierarchy. From here it is possible to access all other areas of the data center, such as MMR, IDA and ZDA.

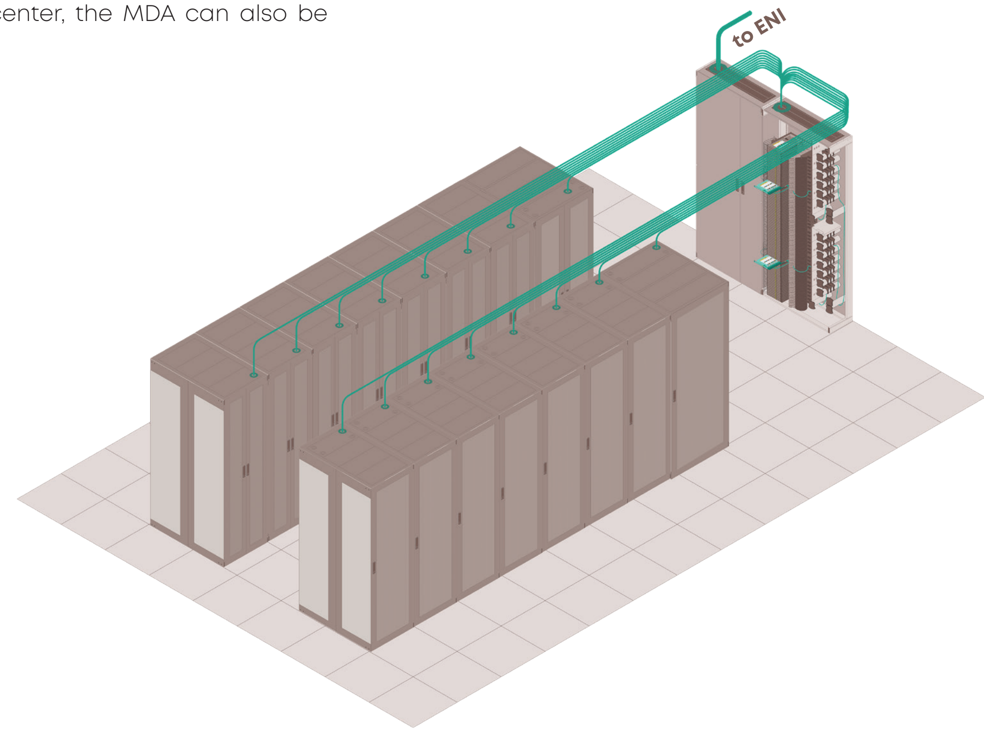
Every data center should have an MDA. Physically it could be a separate room within the data center, a dedicated area inside the data hall or even a whole data hall. Equipment located in the MDA is critical as it serves mainly high-speed links consisting of aggregated traffic. If a separate MMR does not exist then its functions can be integrated into the MDA. The MDA should be defined from the beginning and a growth factor should be considered in the design.

In highly secure data centers there can be two MDAs, so that redundancy can be achieved. Cables connecting redundant MDAs are considered as **backbone (3)** and they provide connections between redundant signal paths.



MDA combined with ZDA

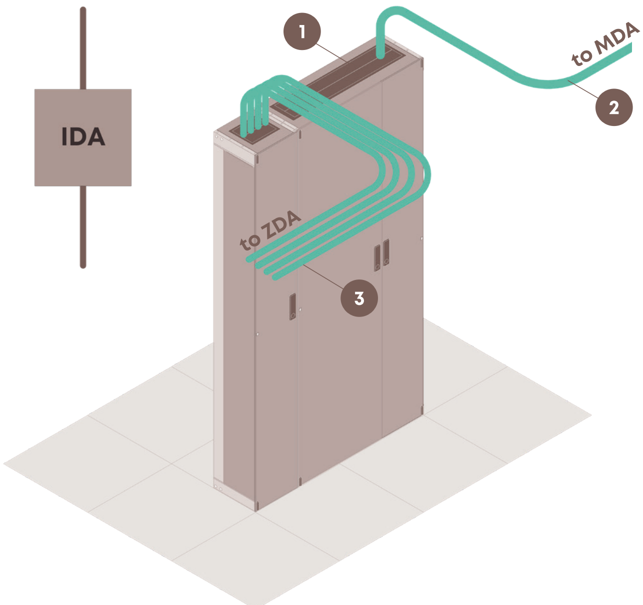
In a smaller scale data center, the MDA can also be combined with a ZDA.



Intermediate Distribution Area (IDA)

Finally, an IDA can be found in large-scale data centers with significant numbers of data halls located on different floors. To achieve flexibility for interconnections, several zones can be aggregated in the IDA. There is less need to create intermediate distributors in mid- or small-scale data centers.

It can be equipped with an **ODF (1)** which is connected from one side to the **MDA (2)** and from other side to different **ZDAs (3)**. Some aggregation switches could also be located in proximity to the IDA.



Horizontal cabling variations

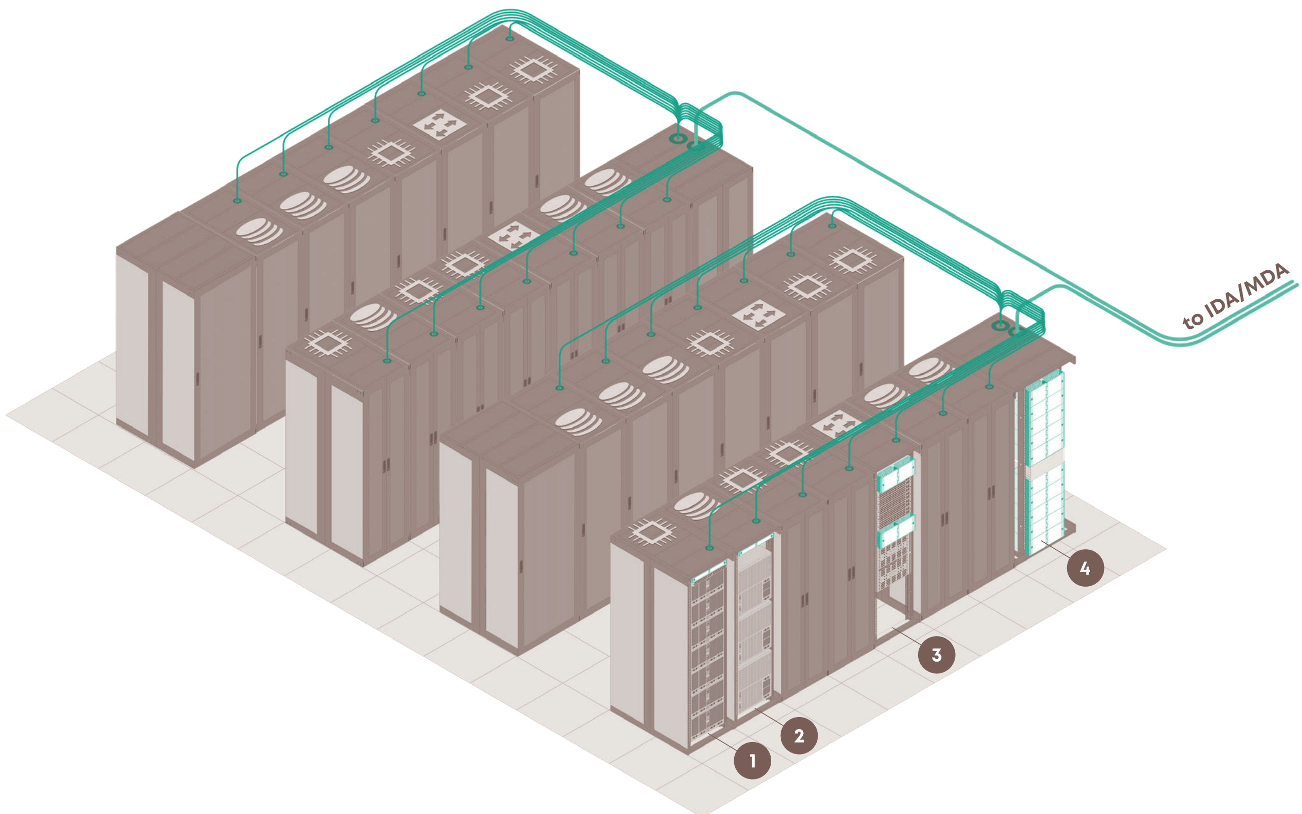
Data hall and horizontal cabling

A data hall is a room in a data center which is separated from other auxiliary rooms. The data hall contains a large amount of equipment cabinets which are formed into rows. Cabinets can be fitted with different **equipment servers (1)** and **storage drives (2)** which belong to one or many owners. Some of the racks are equipped with aggregation or **spine switches (3)** whose main function is to aggregate traffic from a group of cabinets and provide access to the upper level of the network. That could include connectivity to intermediate and core levels or to other spine switches to reach equipment in other data halls or outside the data center.

Usually mid- and large-scale data centers have several data halls or segments. Small-scale data centers which can belong to a single company can have only one data hall.

The **ZDA (4)** is the node of structured cabling system which is located in the data hall and is the point of consolidation of cabling from equipment located in a cluster of racks. It is passive, which means it has no power and cooling demands.

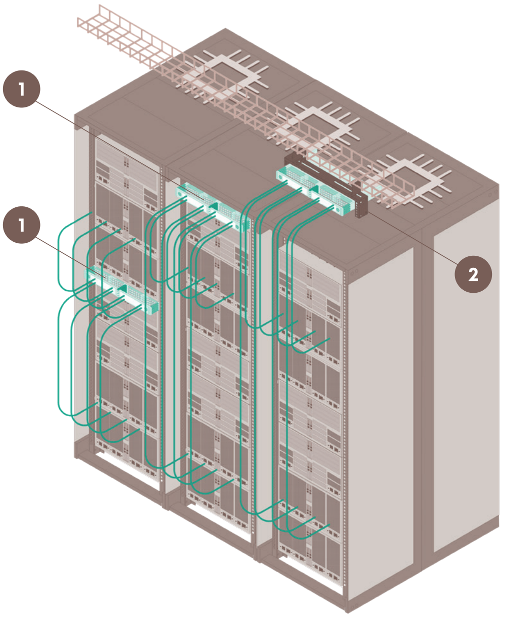
There are usually two distributors so that redundancy can be achieved. For flexibility additional cabling can be added connecting ZDAs within the data hall. However, in many cases the additional cabling is not necessary. The link between reserved switches can be done through the MDA or IDA, if existing.



Equipment outlet (EO)

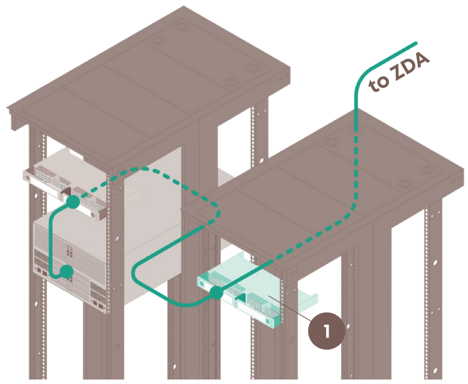
EO (1) is the end node of the structured cabling. In general, it looks like a 1U panel at the top of the rack or can be a box or adapter plate placed within the rack. In this case, it is termed “zero space” due to it not using the rack's useful “U” space. From the EO there is a last connection either to the top of the rack switch or directly to the server or storage equipment.

EO can also be located in the middle of the rack, in the vertical cavity of the rack (if space allows) or, for example, outside the rack mounted to the **raceways (2)**.



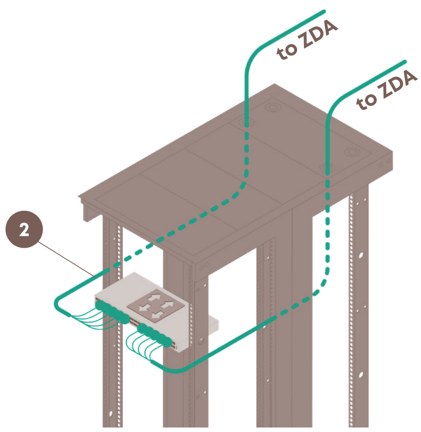
Local distribution point (LDP)

LDP (1) is also termed a consolidation point, and can physically look like the EO but it serves as a small distributor, serving a smaller number of racks. It is not common for fiber horizontal cabling, because each interconnection adds loss to the channel, but it is popular for copper cabling as it improves installation time.



Port replication

Replication of equipment **ports cabling (2)** is a type of horizontal cabling without EO and LDP. It is a very efficient method to present switch ports into the ZDA as it directly connects equipment within the ZDA, bypassing the intermediate connections (EO or LDP). It is a common practice to use harness cables to connect switch transceivers and patch panels replicating these ports on the ZDA.



Horizontal cabling variations

Interconnect horizontal cabling

This approach locates the ZDA and aggregation switches in the same rack. EOs are connected to the ZDA. The equipment cords (patch cords) connect the hardware (server, storage or ToR switch) to the EO which is connected to the aggregation switch via ZDA.

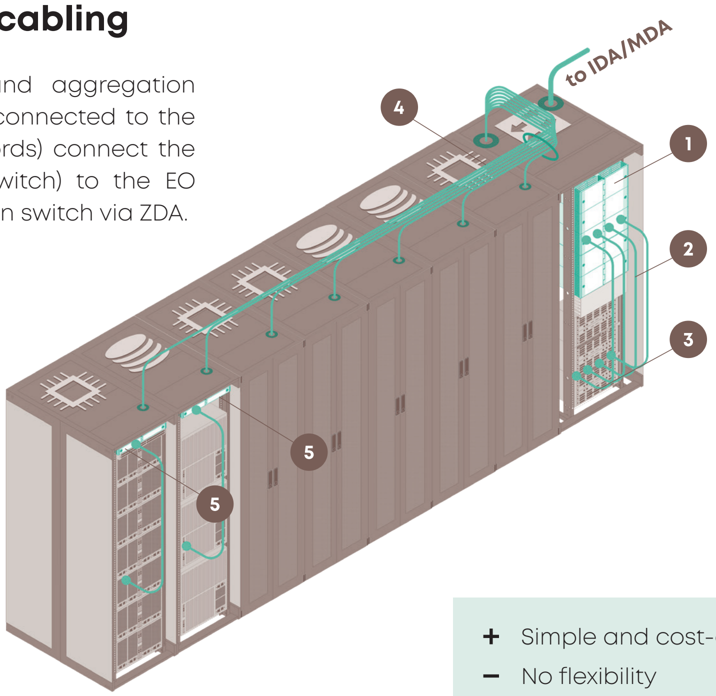
(1) ZDA

(2) Interconnects to switch

(3) Switch

(4) Horizontal cabling

(5) EO



+ Simple and cost-effective
– No flexibility
– Limited upgrade potential

Cross-connect horizontal cabling

In the cross-connect horizontal cabling design the aggregation switch is located in a separate rack. EOs are still connected to the ZDA, but the aggregation switch is also connected to the ZDA using the same principle as the server. Connections between the switch and server are then done with the cross-connect method.

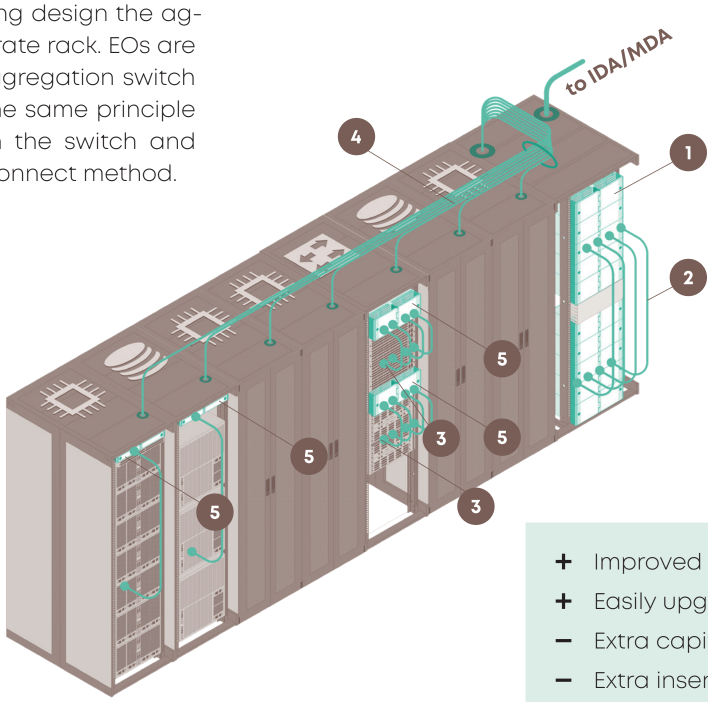
(1) ZDA

(2) Cross-connects

(3) Switch

(4) Horizontal cabling

(5) EO



+ Improved flexibility
+ Easily upgradeable
– Extra capital costs
– Extra insertion loss

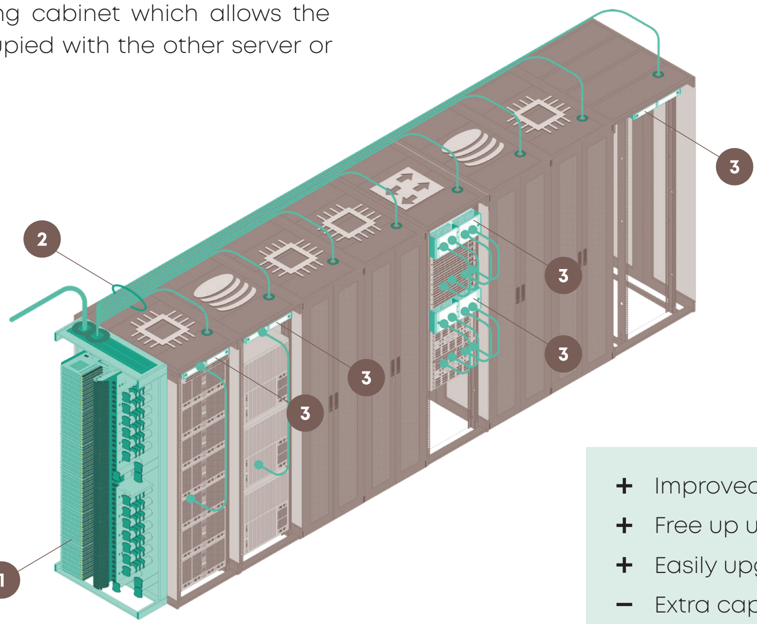
Cross-connect topology with ODF

The ZDA is a free-standing cabinet which allows the unused space to be occupied with the other server or switch equipment.

(1) ZDA

(2) Horizontal cabling

(3) EO



- + Improved flexibility
- + Free up useful rack space
- + Easily upgradeable
- − Extra capital costs
- − Extra insertion loss

Minimise cost and extra loss with port replications

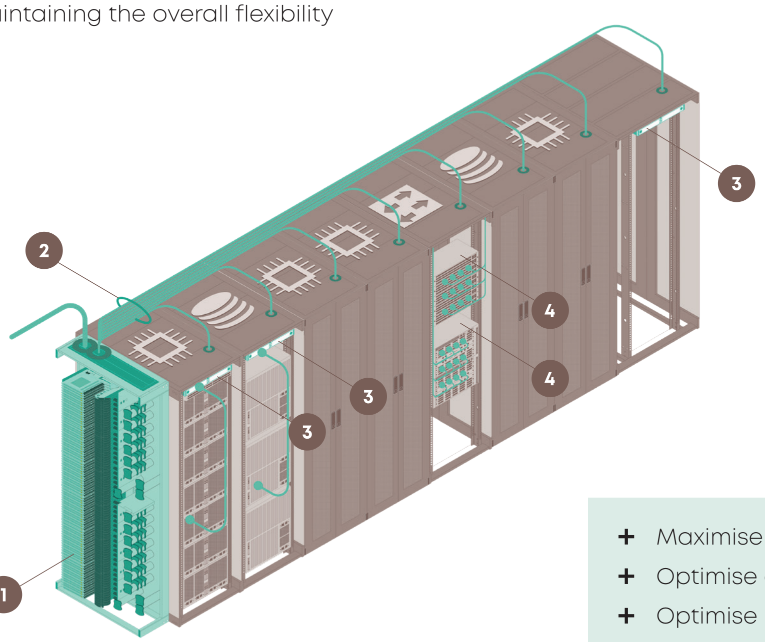
Replacing the EO in the switch rack with a port replication design maximises useful space, minimises cost and optical loss, while maintaining the overall flexibility of the cross-connect.

(1) ZDA

(2) Horizontal cabling

(3) EO

(4) Port replication

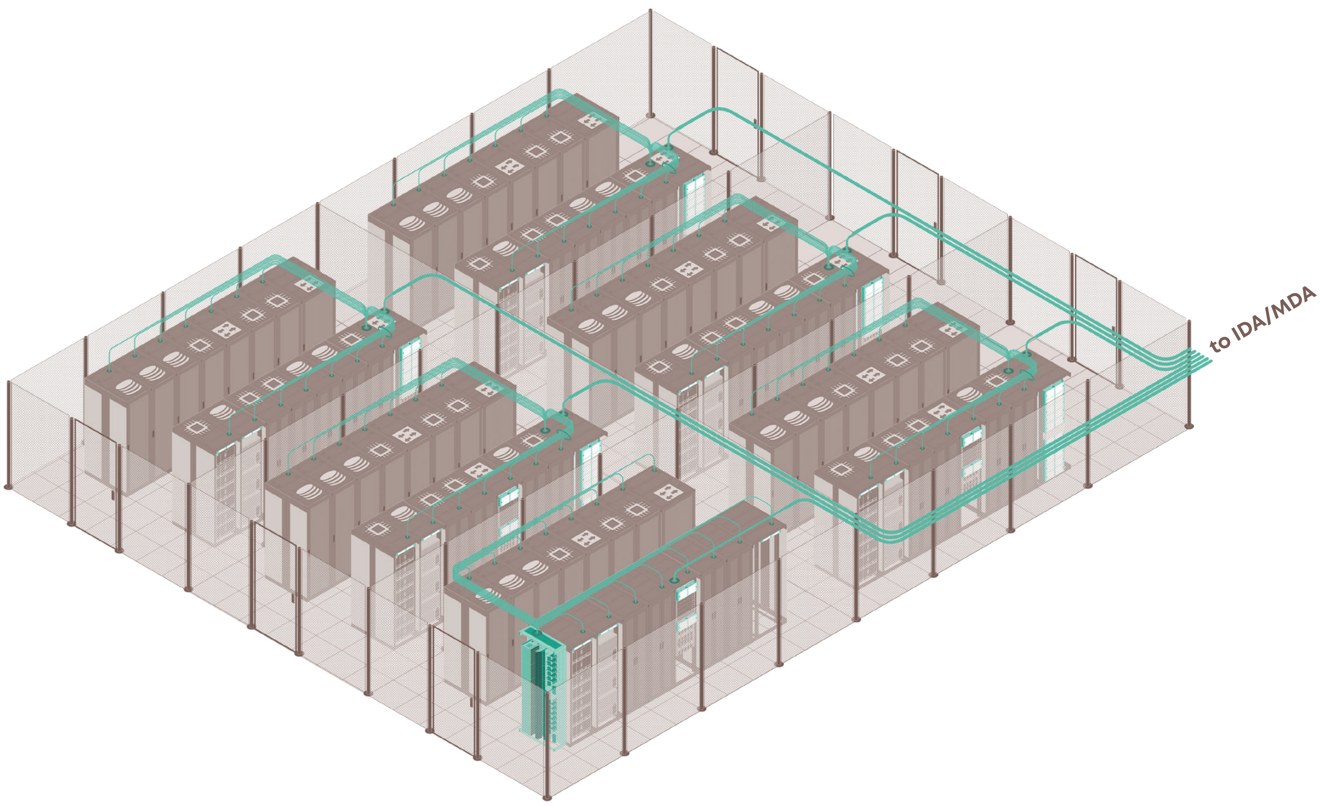


- + Maximise useful space
- + Optimise costs
- + Optimise insertion los

Horizontal cabling explained

Multiple zones in a data hall

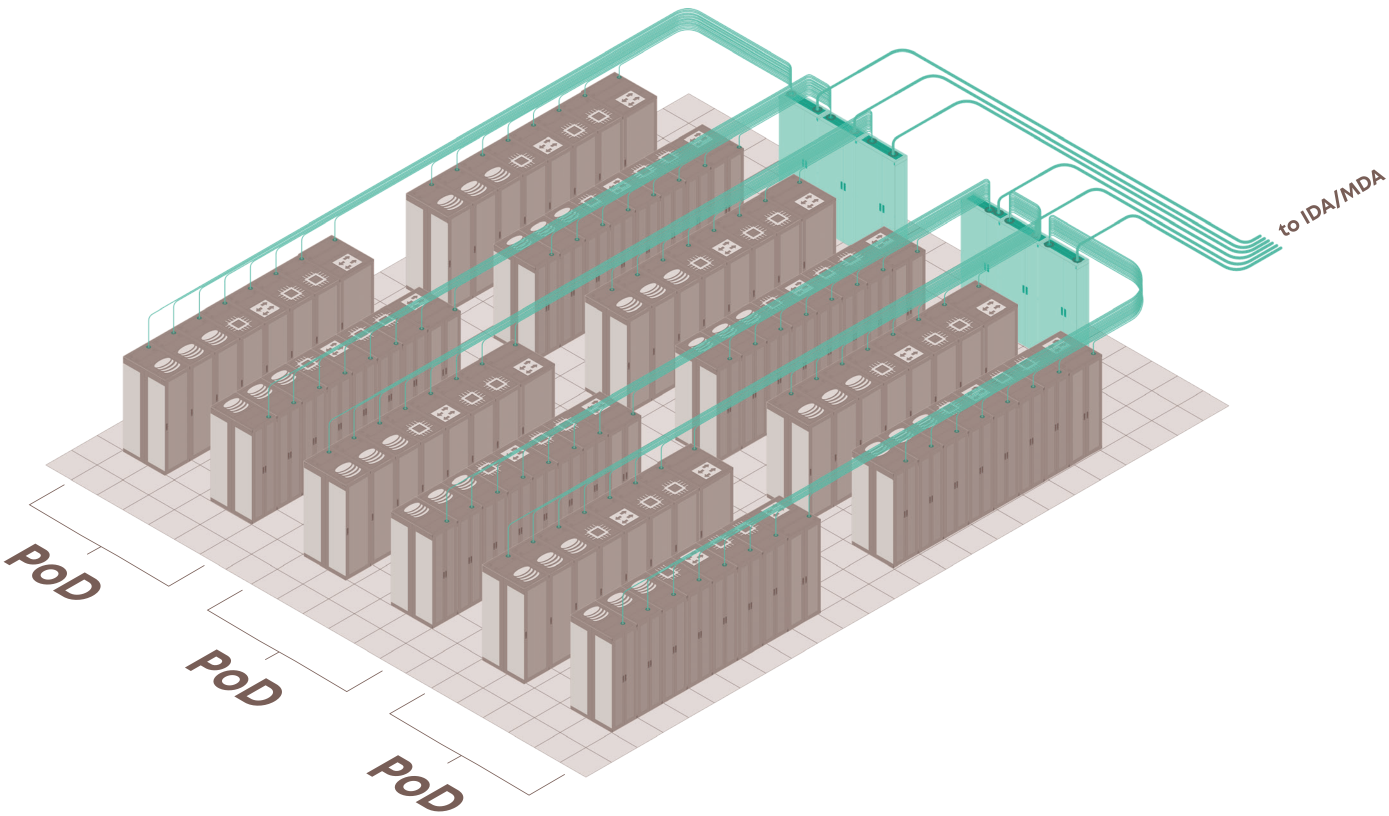
Colocation data centers provide white space, where customers can install and operate their equipment. The data hall can be divided into smaller zones, where each can belong to different customers, called customer cages. Every cage will have an individual ZDA which is connected to the MDA or IDA.



- **+** Each customer is responsible for their own area and cage cabling is done individually
- **–** Not possible to establish connections between customer cages which are done through higher level distributors

Single zone in a data hall

In contrast, some data halls can be occupied by one customer or may be a single enterprise data center, where racks are organized by group called, Point of Delivery (PoD). ODFs within ZDAs can be placed side-by-side or back to a wall which allows the creation of one larger ZDA. This gives more flexibility to connect various switches to various servers that are not necessarily from the same PoD. This also provides the possibility to move and change equipment in an entire data hall and still be connected to each other.



- Flexible to establish connections between any equipment in a data hall
- Cabling adheres to certain principles using typical links

Transmission media

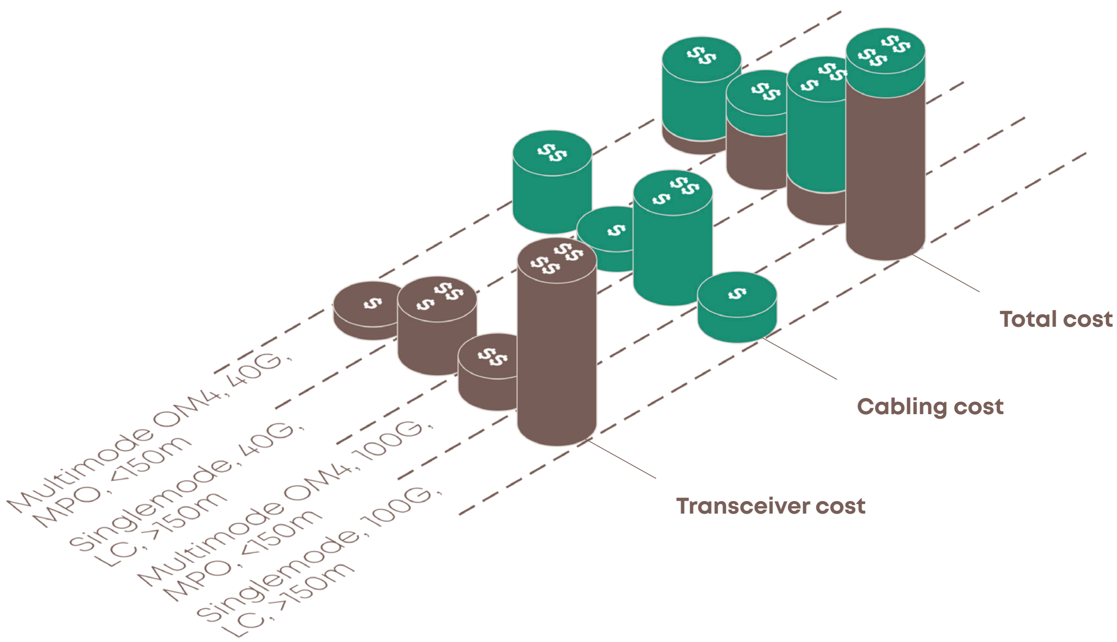
Backbone cabling options

Singlemode (SM) optical fiber is a prevalent fiber for backbone cabling as it has near-infinite bandwidth and a lower attenuation per unit length compared to multimode (MM) cables. SM provides more possibilities for bandwidth expansion.

The optical loss budgets for transceivers are also greater for SM than those for MM. The link distances for backbone cabling are significantly longer than those of horizontal cabling, which gives SM a clear advantage.

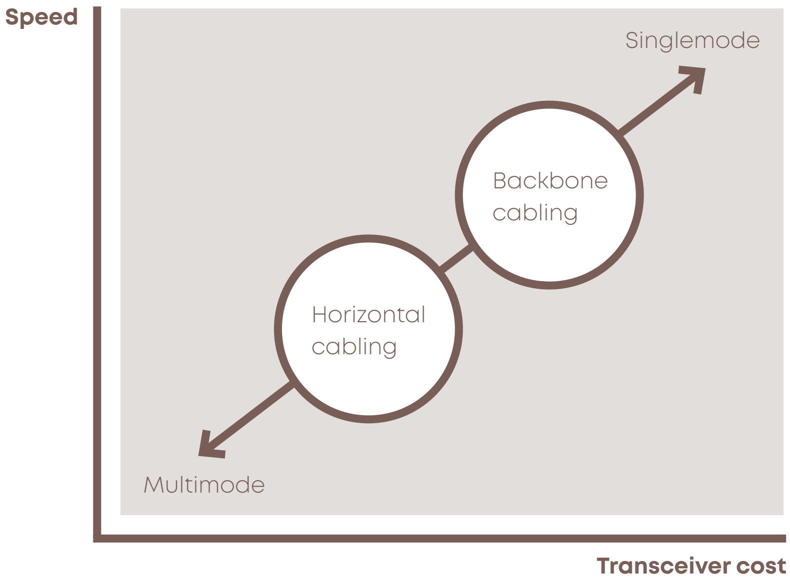
SM transceivers are usually more expensive than MM transceivers. This makes MM transceivers the best choice for data center applications like SAN cabling.

Copper backbone is still used for telephony and legacy connections, but this is more of an exception in new builds.



Horizontal cabling options

Horizontal cabling typically uses both SM and MM optical fiber-based products. Horizontal cabling doesn't require such high speeds as the backbone, but a greater number of connections need to be deployed. As shown in the bar chart on the opposite page, a SM transceiver at higher cost in combination with a lower cabling cost results in a similar total cost to the MM, where the transceiver cost is lower but cabling is more expensive. For even lower speed connections MM is more prevalent than SM.



Copper connections

Copper is still used extensively for out-of-band connections for management and monitoring of various types of communications equipment and servers. While it can be maintained by an optical system, the device connection typically remains balanced copper.

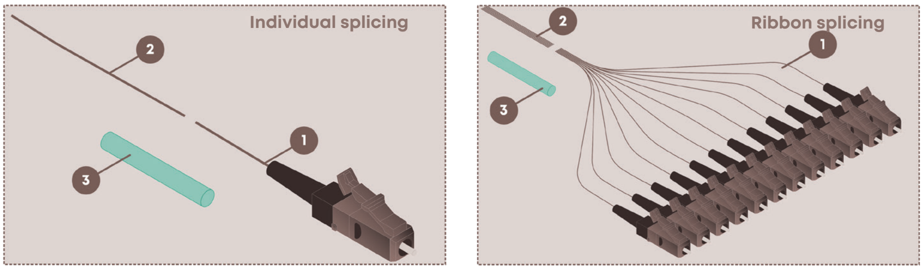
Splicing and patching

Splicing

The splice method of connecting fiber optic cables to each other and to connectorised assemblies (pigtails) is currently the most popular connectivity method. The pigtail is fusion-spliced (welded) to an optical fiber from within a cable. This is the most common method of terminating a cable with a connector and requires dedicated splicing equipment. Groups of spliced fibers from that cable are then protected, coiled and packed inside the splicing module or cassette. In a data center structured cabling design, the fusion-splice method is often used, however, due to the time needed for splicing, other connectivity methods seem to be preferred.

Ribbon splicing (splicing up to 12 fibers, arranged as a flat ribbon simultaneously) enables a significant reduction in splicing time but is still more time consuming compared to pure “plug-and-play” methods.

1. Splicing elements

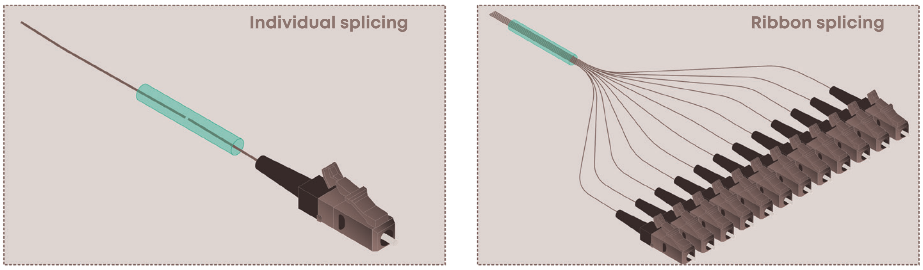


(1) Individual or ribbon pigtail

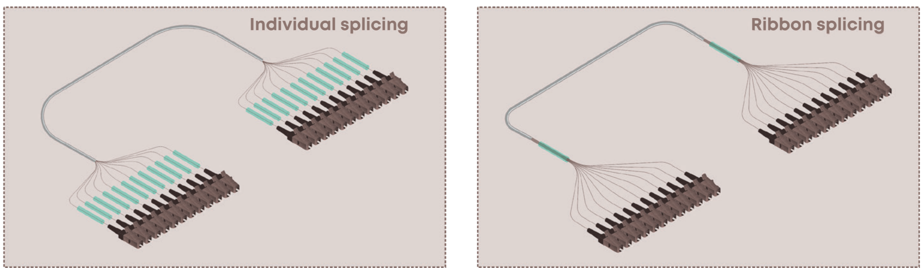
(2) Individual or ribbon fiber

(3) Individual or ribbon splice protector

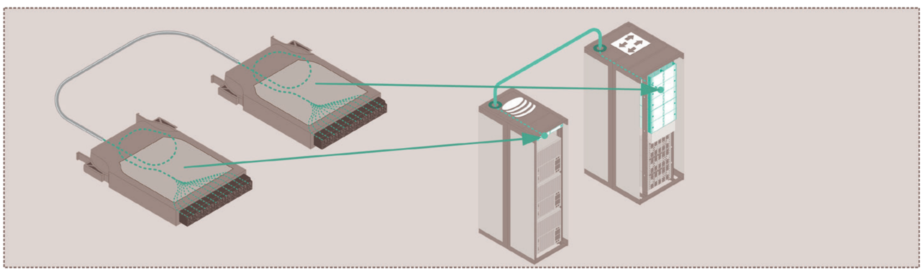
2. Fusion spliced fiber or ribbon fiber



3. Cable terminated both sides using splicing method



4. Data center link with splicing modules

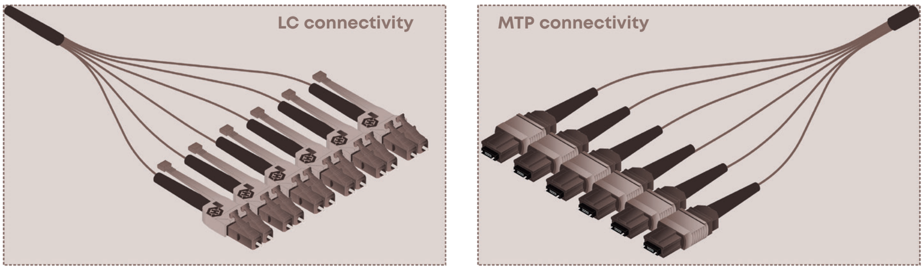


Patching

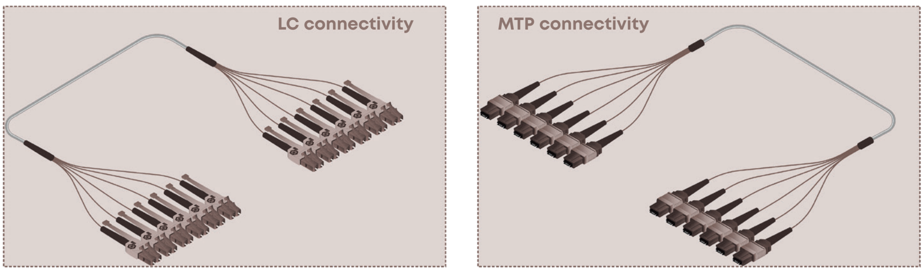
Cable systems consist of a cable which has been pre-terminated with connectors. The patching method assumes installation of cable systems which are directly plugged into the distributor without any transition. Patch cords require the same connector as the cable system.

Splicing provides better optical link performance compared to the patching method, but also takes longer to install. However, there is another fundamentally different method which requires even less time. It is called multi-fiber termination push-on (MTP). The MTP-based "plug and play" method utilises transition cassettes.

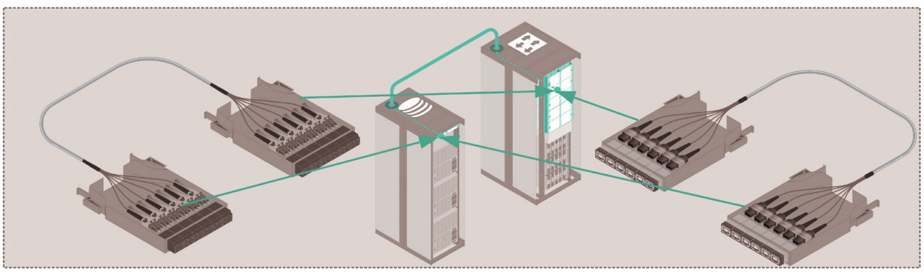
1. Cable terminated with connectors



2. Cable terminated both sides



3. Data center link with patching modules



Please note

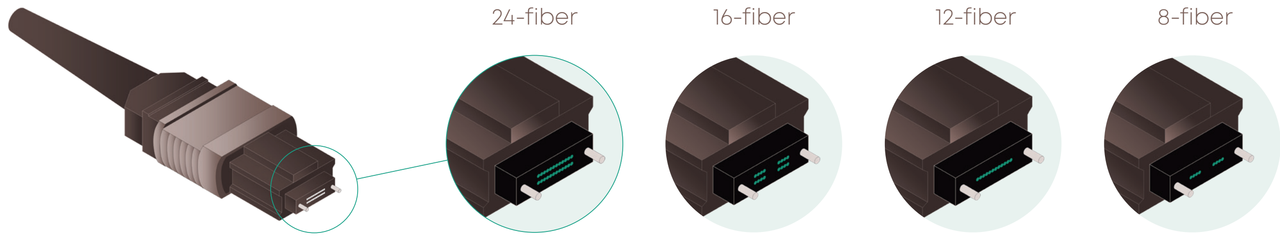
With less intermediate mated connectors in the full link, splicing and patching provide the best optical performance, however require more time for installation.

MPO/MTP base methods

MPO/MTP connector

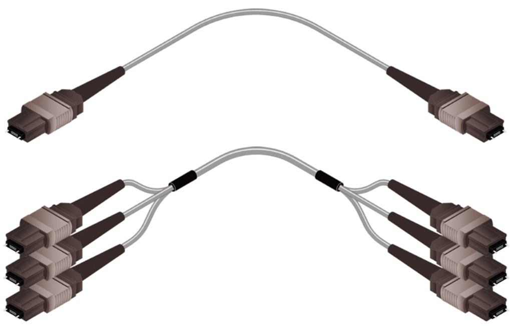
Multi-fiber push-on (MPO) or multi-fiber termination push-on (MTP), a premium MPO connector is a gender-specific multi-fiber connector which can connect multiple fibers (usually 8, 12, 16 or 24). This is the fastest method when used in a structured cabling design for simultaneous connection.

There is another variety of MPO connectors (16 or 32 fibers) with some additional differences, however these are not yet commonly used as an infrastructure connector.

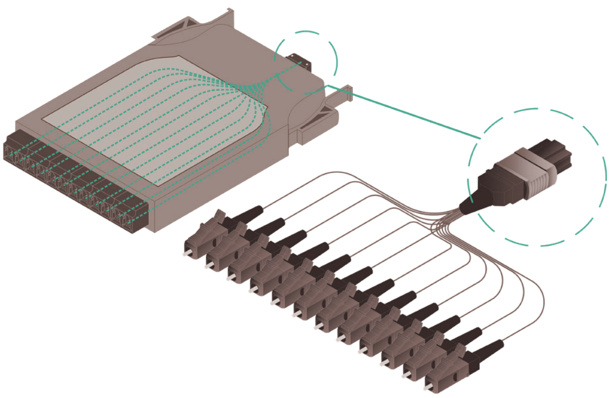


MPO/MTP trunks

A trunk is defined as sufficiently ruggedised cable that is terminated on both sides with one or more MPO/MTP connectors which can be installed between nodes of structured cabling or between racks. Trunk types can vary due to different configurations of connectors used, gender and optical fiber quantities within the trunk. Trunk cables usually use larger cable diameters due to the strength and fire performance required.



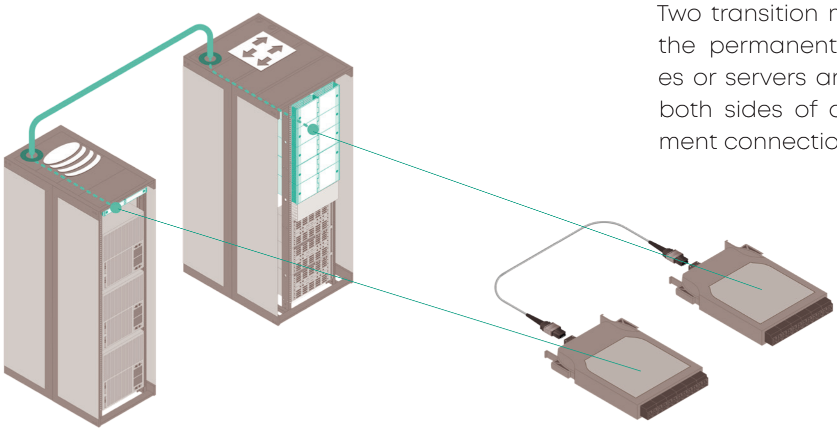
Transition modules/cassettes



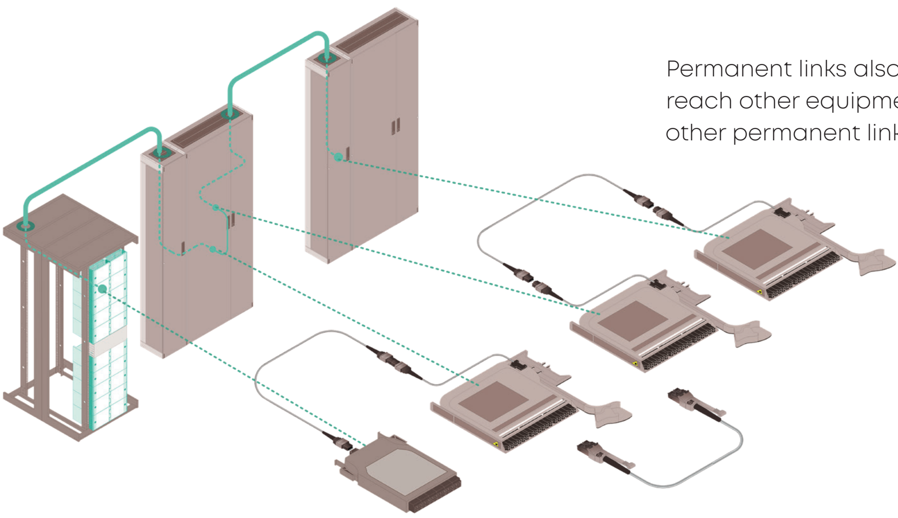
Transition modules or cassettes are so named because the transition between one type of connector (MPO/MTP) to another type, generally LC or SC connectors.

MPO/MTP connectors have different numbers of fibers and can be of male or female gender. Each can be configured with several connection schemes which have respective transition modules that take into account the differences.

Permanent link



Two transition modules connected with a trunk forms the permanent link. Finally transceivers from switches or servers are connected with equipment cords to both sides of a permanent link to create the equipment connections.



Permanent links also connect distribution areas and to reach other equipment they may also be connected to other permanent links.

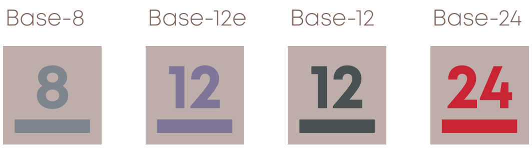
Please note

The MTP-based method allows to provision rapid data center links

Base connection methods

The MPO/MTP-based connection method involves the use of:

- a specific type of transition module
- a specific trunk cable



Fiber products are designed to work for a specific method and may not be compatible with products designed for another method. HUBER+SUHNER recommends 4 base methods; Base-8, Base-12, Base-12e and Base-24, where the number specifies the quantity of fibers terminated in the MTP/MPO connector. There are advantages and disadvantages in implementing all of these methods, but those are not covered in this white paper. Permanent links also connect distribution areas and to reach other equipment they may also be connected to other permanent links.

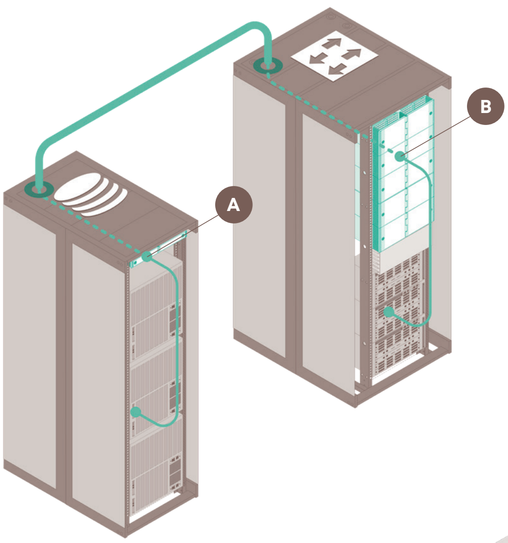
Data center typical link

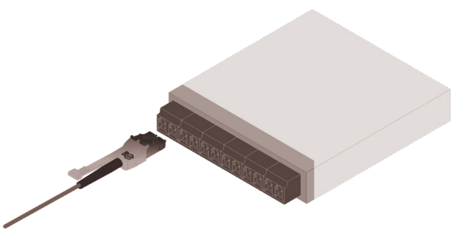
Data center link designs

The way in which the nodes in a structured cabling design can be linked depends on:

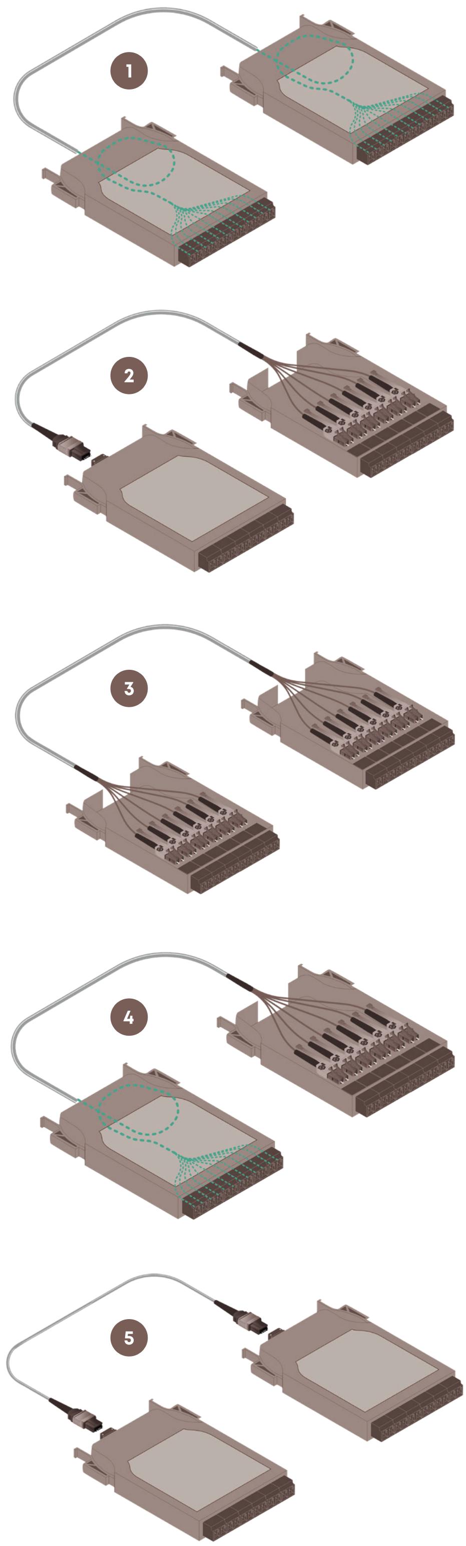
- connection methods: MPO/MTP-based / splicing / patching
- transmission media – fiber types (SM or MM)
- connector types (e.g. LC, MPO/MTP, SC etc.)
- patch panels styles and ODFs
- product configuration (polarity, number of circuits etc.)

The combination of these factors leads to the large number of variations or link designs. For example, any of the presented link designs from **(1)** to **(5)** can be used to connect node **(A)** to node **(B)**.





For the technician doing patch cord connections it may not be noticeable what method is used. That is because when viewed from the front, all links (like in the above example) will have the same view.



Data center typical link

A data center typical link is a combination of products based on a certain link design. The link design can be used as a template, which can be deployed in different situations, including the backbone or horizontal cabling.

A typical link will include several products with unique configurations that form the bill of material. It is the responsibility of the cabling planner to pre-select the appropriate products to form the typical link.

The technical prerequisites to consider are: required connectivity, transmission media, transceiver types, installation time and access to splicing equipment.

The total number of deployed typical links multiplied by the number of products in each link gives the total quantity of required products for the entire installation.

Data center link examples

#	Data center typical link	Installation speed	Quantity	Total quantity
1	**Splicing link, bill of material**		**α**	
	Cable for splice	Slow	1	1*α
	Splicing module or cassette	Slow	2	2*α
2	**MTP-based + patching link, bill of material**		**β**	
	Cable system MTP to LC duplex	Fast	1	1*β
	Patching module or cassette	Fast	1	1*β
	Transition module	Fast	1	1*β
3	**Patching link, bill of material**		**γ**	
	Cable system	Average	1	1*γ
	Patching module or cassette	Average	2	2*γ
4	**Splicing + patching link, bill of material**		**δ**	
	Cable system one side terminated	Below average	1	1*δ
	Splicing module or cassette	Below average	1	1*δ
	Patching module or cassette	Below average	1	1*δ
5	**MTP-based link, bill of material**		**ε**	
	MTP trunk cable	Fastest	1	1*ε
	Transition module or cassette	Fastest	2	2*ε

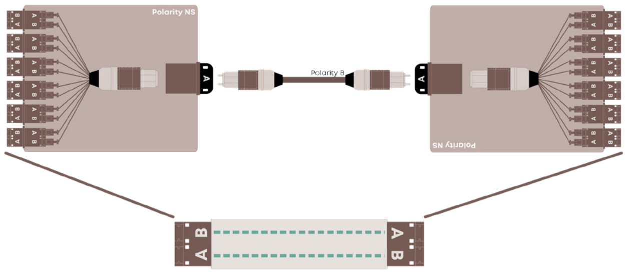
Permanent link and channel

Permanent link

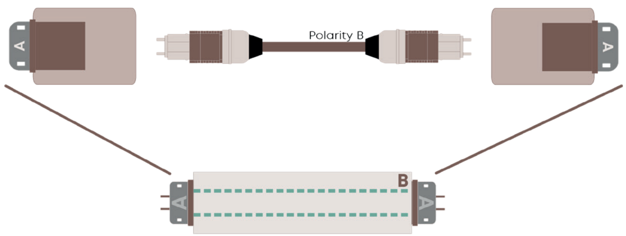
The **Permanent link (PL)** of a SCS consists of the cabling (whichever type) between the user-accessible interface adapters which are connected by that cabling. It is assumed that everything in between is installed for long-term use. Often, a data center typical link also represents a permanent link.

After installation, the PL should be examined, tested, documented and verified. By adding patch or equipment cords to the PL we can connect transceivers or connect to another other PL. Cabling (a combination of permanent links and patch cords) between transceivers, with the exclusion of the plug that fits into the transceivers, forms the cabling channel.

A PL gives confidence and assurance that after adding a patch cord it is possible to build reliable channels. In the case where a cabling upgrade takes place, it must then be re-examined as interfaces were changed and might have been disturbed or damaged.



Schematic illustration of permanent link



Examples of permanent link

Duplex to duplex, polarity A-B/B-A

Duplex to duplex, polarity A-A/B-B

MPO 8-fiber to MPO 8-fiber, male to male, polarity B

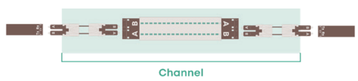
MPO 12-fiber to MPO 12-fiber, male to male, polarity B

MPO 12-fiber to MPO 12-fiber, female to female, polarity A

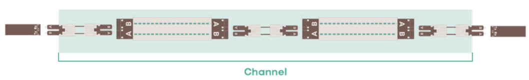
MPO 24-fiber to MPO 24-fiber, male to male, polarity A

Duplex to MPO 8-fiber, male, polarity NP

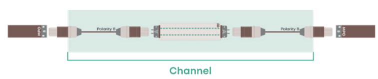
Examples of channels



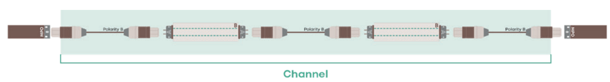
Duplex transceiver inter-connect channel with A-B permanent link and two A-B patch cords



Duplex transceiver cross-connect channel with two A-B permanent links and three A-B patch cords



MPO 8-fiber transceiver inter-connect channel with one permanent links (Type B) and two type B patch cords



MPO 8-fiber transceiver cross-connect channel with two permanent links (Type B) and three type B patch cords

Connection methods

Connection methods

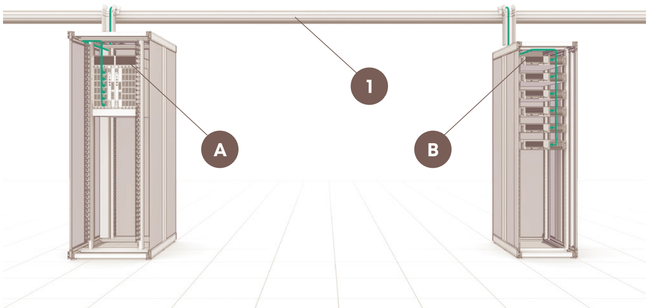
The **direct-connect method** is a channel without any permanent link. It is a valid method of connecting equipment, for example, when connecting nearby equipment within the same rack or when replicating equipment on to the distributor.

Direct-connect should not be used as a common approach in the data center because this tends to lead to a tangled cabling effect often referred to as "spaghetti".

Active optic cables (AOC) with transceivers integrated on both sides are one variety of direct-connect cabling. They provide an easy and fast way to deploy optical links as no fiber cleaning, polarity or gender check are required. Additionally, they mitigate human error caused by improper connection and can be more cost effective than using separate transceivers and patch cables.

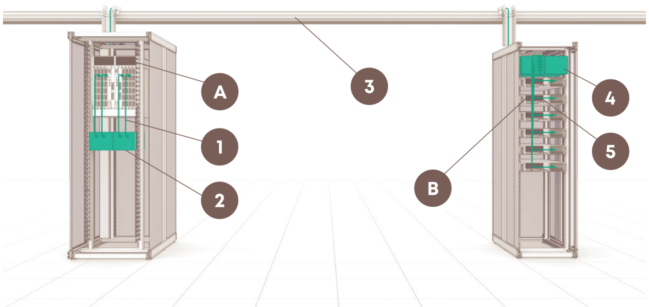
The **inter-connect method** includes a channel which has only one permanent link. For example, one side is connected to a server with an equipment cord and another side is connected to a switch.

The **Cross-connect method** includes more than one permanent link. For example, when horizontal cabling from all of the equipment (switch, server) is centralized, the connection between them is performed by connecting corresponding adapters inside the cross-connect patching area.



Direct-connect

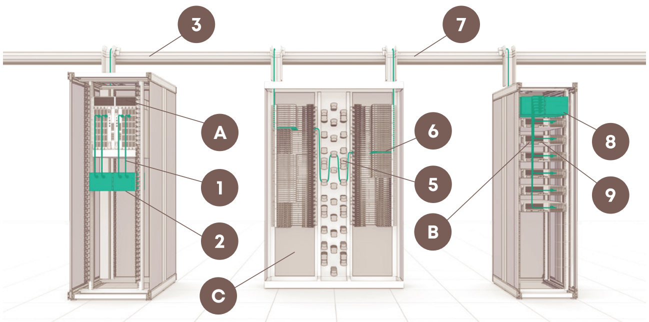
(A) Switch
(B) Server
(1) Patch cord or AOC



Inter-connect

Permanent link

(A) Switch
(B) Server
(1) Patch cord, switch side
(2) Module, switch side
(3) Trunk
(4) Module, server side
(5) Patch cord, server side



Cross-connect

Permanent link

Permanent link

(A) Switch
(B) Server
(C) ODF
(1) Patch cord, switch side
(2) Module, switch side
(3) Trunk or cable
(4) Module in ODF, switch replication
(5) Patch cord, cross-connect
(6) Module in ODF, server replication
(7) Trunk or cable
(8) Module, server side
(9) Patch cord, server side

MPO/MTP upgrade path

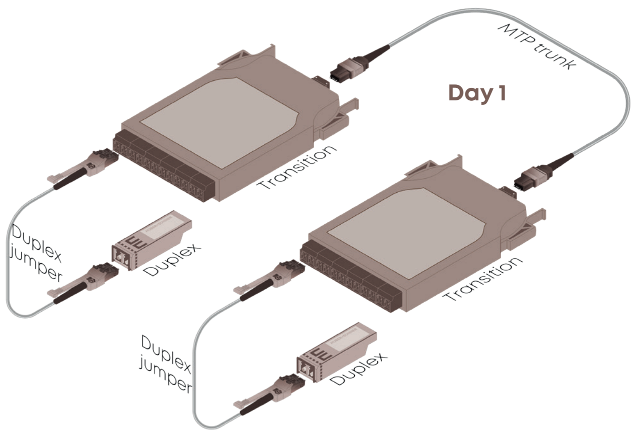
Upgrade path

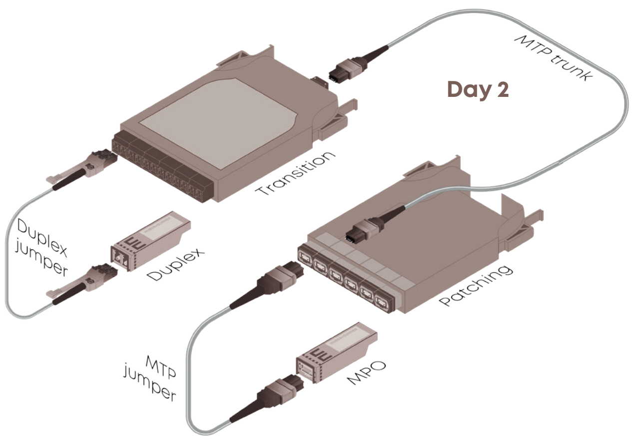
The question of an upgrade path addresses the need of adapting the cabling if the transceiver is replaced with another design. The newer one may have a different physical interface (connector) which is not compatible with the deployed connector. MPO/MTP base methods allows the re-use of installed trunks adapted for use with other connector types. Depending on the typical link and defined base types there are different ways to re-use trunks and jumpers. These are called upgrade paths.

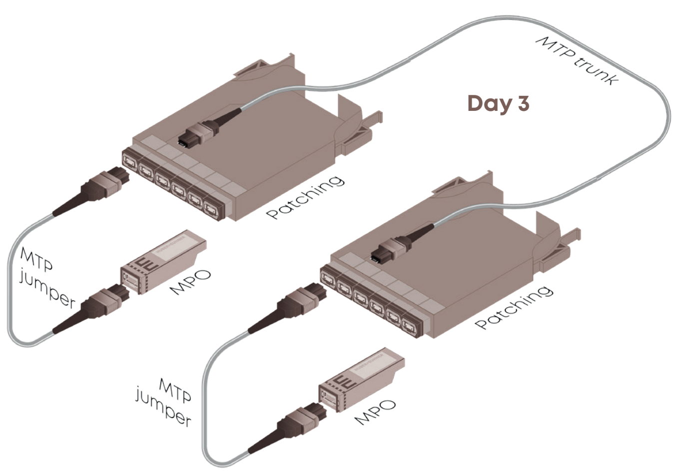
(1) In this example, on Day 1 there is a duplex link, consisting of two transition modules and a trunk between them.

(2) On Day 2, one of the duplex transceivers is replaced with a multi-fiber transceiver. The transition module on one side is replaced with an MTP patch cord. The resulting link is MTP to duplex.

(3) On Day 3, the second transceiver is also replaced with a multi-fiber transceiver. The second transition module is also replaced. It uses the same trunk but now connects new and different transceivers. Splicing and patching termination methods are less universal as they do not have the possibility of switching to other interfaces.







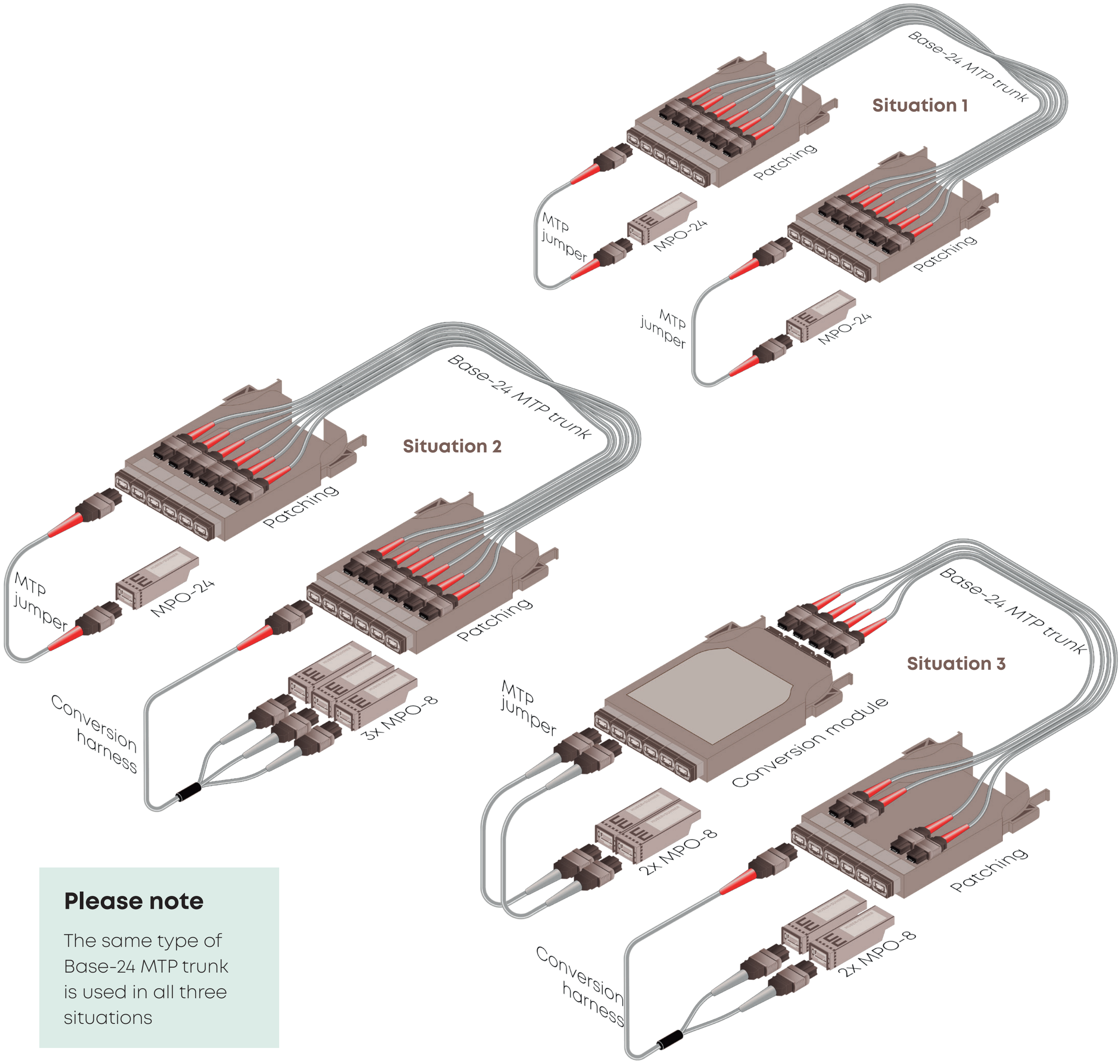
Please note

The same MTP trunk is used throughout the entire life cycle of the optical link.

MPO/MTP conversion

Conversion

Conversion is a type of transformation from one MPO/MTP connector type to another. It is very often used in upgrade paths when the new transceiver interface does not match the trunk cabling interface. For example, the trunk may have a 24-fiber MTP connector, but the transceiver has MPO 8-fiber interface, or vice versa. Conversion can be used in modules or in harness cables.



Please note

The same type of Base-24 MTP trunk is used in all three situations

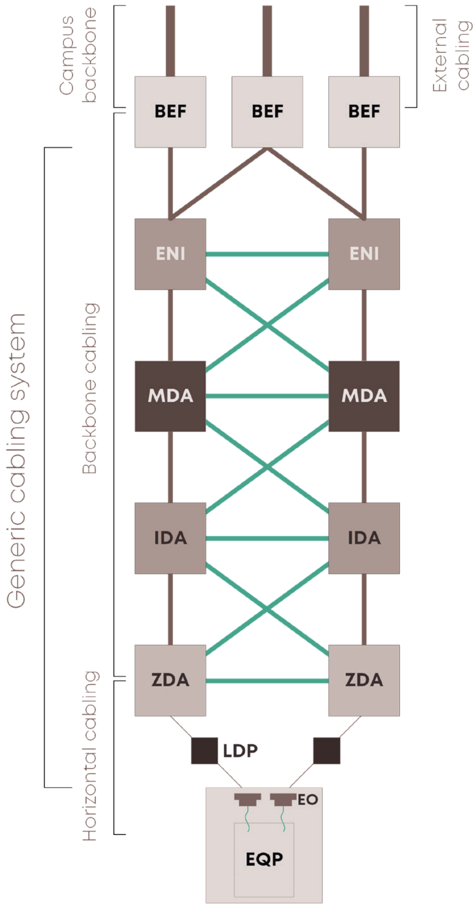
Redundancy

Redundancy

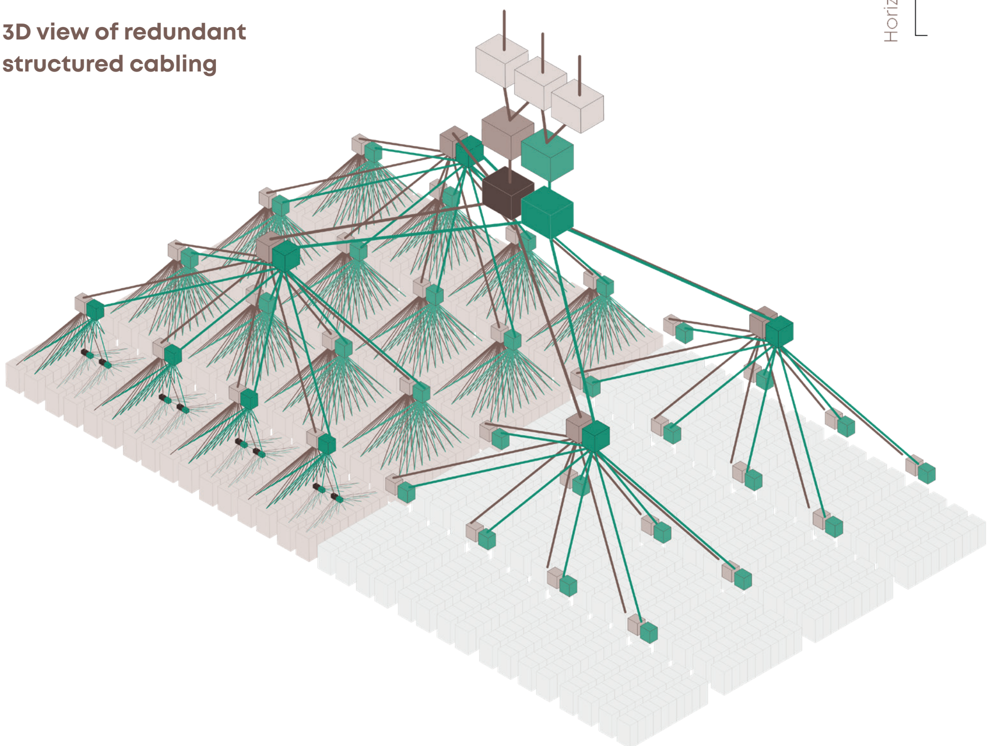
IT infrastructure located in data centers is often business critical for enterprise companies and therefore requires full availability. One way to achieve maximum uptime is by duplication of the data center facility and effectively mirroring its partner facility. This is a robust, but costly method.

Another method involves adding redundant equipment and avoiding single points of failure. For example, when an external service/carrier enters the data center, it can be useful to consider the redundancy of the connections.

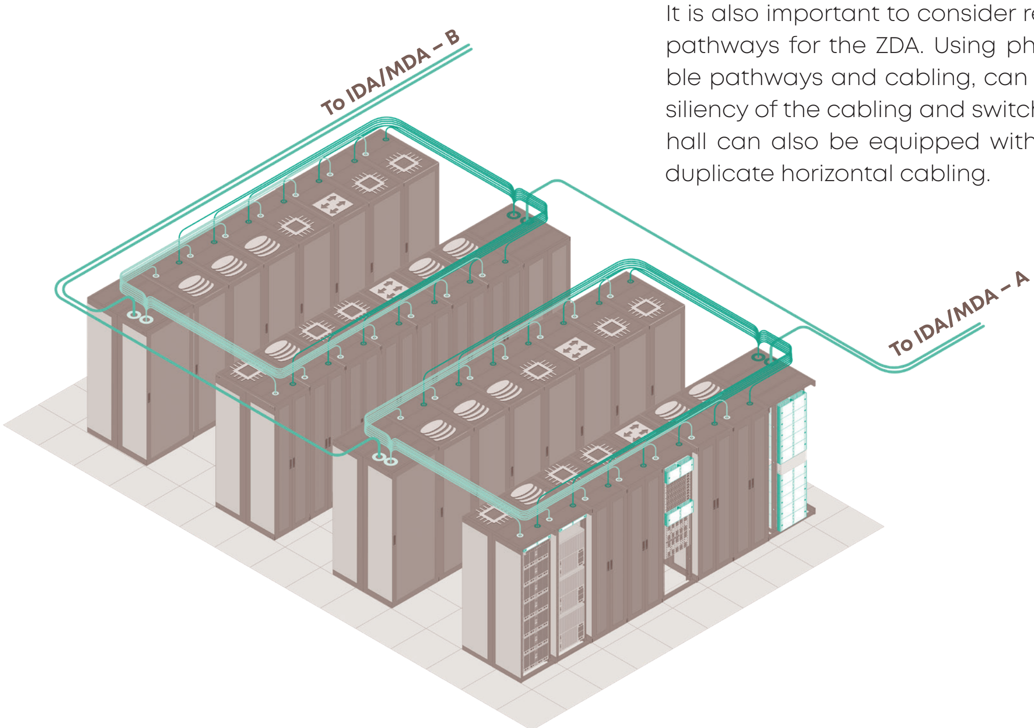
Redundancy through the individual data hall, ZDA or even to the EO in the server rack, ensures all customers within the data center are fed by a minimum of two paths to the outside world or between two in-house locations.



3D view of redundant structured cabling

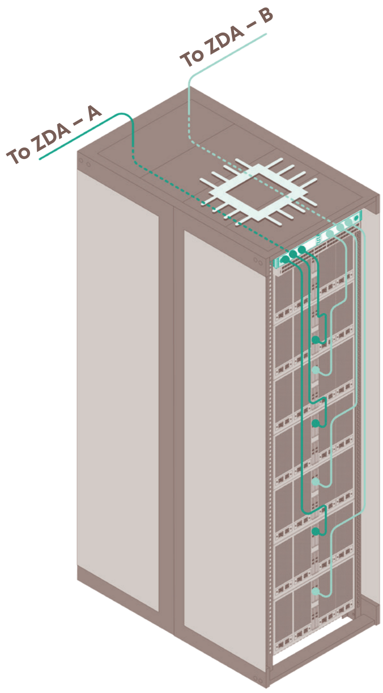


Data hall and horizontal cabling in fault-tolerant scenario



It is also important to consider redundant cabling and pathways for the ZDA. Using physically separated cable pathways and cabling, can further improve the resiliency of the cabling and switching network. The data hall can also be equipped with a duplicate ZDA and duplicate horizontal cabling.

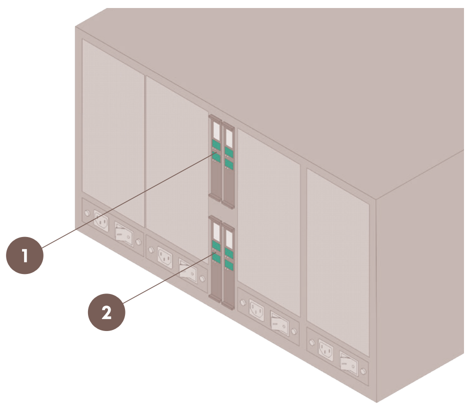
Redundant equipment outlet (EO) scenario



The EO can also be connected to two independent ZDAs. Equipment cords connect the redundant network cards within servers.

(1) PCI card

(2) Redundant PCI card

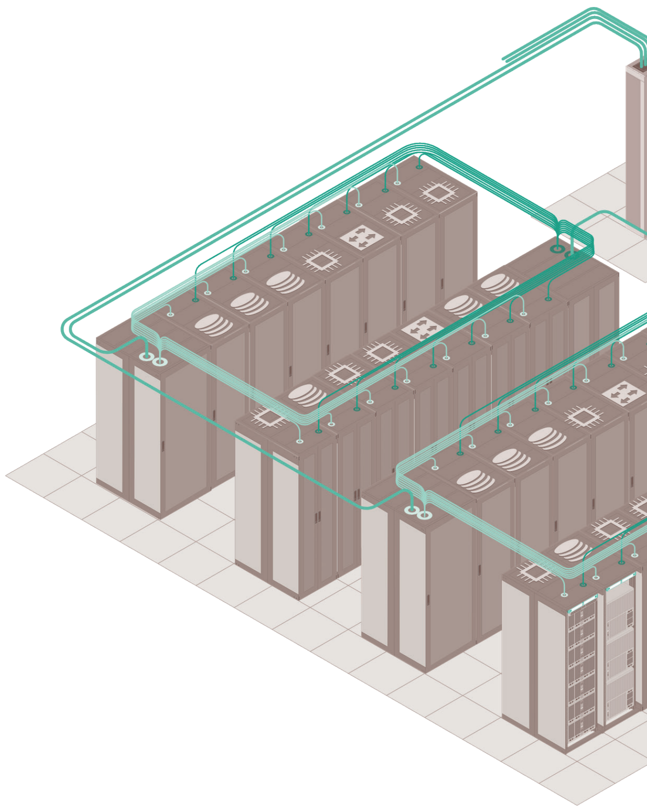


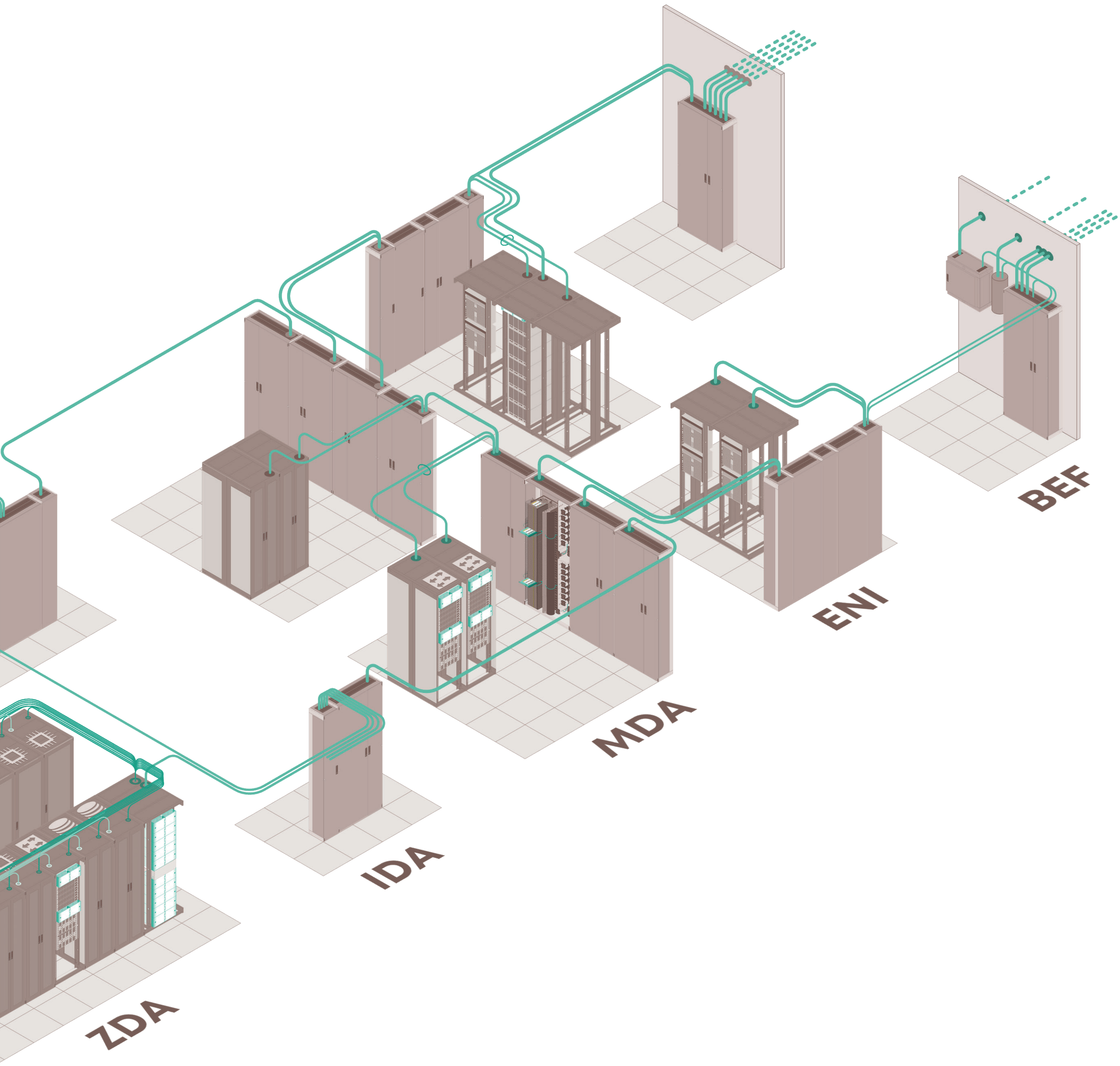
Future proofing – are you ready for the future?

The clear trend of significant growth in data transmission must be reflected by the data center cabling infrastructure. However, a constant increase of capacity can lead to a situation when there is insufficient free space for additional cables and connections. When that happens, the weak point in the process of data center transformation can be backbone cabling. To avoid those challenges, it is critical that backbone cabling has a future-proofed design.

Some examples below should be considered to extend the life cycle of the data center:

- sufficient fibers in the backbone to link different customers with each other within the data center, reducing the need for single point-to-point cables
- enough space in cable shafts, risers, raceways to add more backbone cables
- enough space to place additional cabling racks to accommodate additional cables
- space to place extra racks in the ENI/MMR as more ISPs require access
- smart utilization of fiber backbone to free-up unused ports
- the optimum MPO/MTP-based method chosen and upgrade path considered in advance, which provides efficient scalability options
- scalable fiber management systems that are MPO/MTP-based with easy MACs that support all termination methods, including patching and splicing





BEF
ENI
MDA
IDA
ZDA

Structured cabling technology trends

The projected growth of hyperscale, cloud and colocation data centers around the globe will have a direct impact on how structured cabling evolves. This definitely needs to be considered when planning your data center cabling for tomorrow's needs. The evolution of 100GbE bandwidths is well underway, while 400GbE is just around the corner. Lower latency will certainly support mission-critical applications and require more automation and remote maintenance from a cabling infrastructure perspective. In general, digitalization will define what the data center will look like. Let's take a closer look at the biggest trends:

Sustainability

The fact that data centers require a large amount of energy to be fully operational is no longer a secret. On the contrary, data centers are responsible for 3-5% of global electricity consumption – and the trend is rising. Of course, the focus is on the big power guzzlers like cooling and active equipment.

That's why it's important to work with companies that place great emphasis on sustainability, be it through shortened delivery routes, green production and environmentally friendly packaging. Corporate and social responsibility is one of the focal points at HUBER+SUHNER.

Flexibility

The life cycle of active equipment or hardware is projected to be around 3-5 years – not because they are not designed to operate longer but because they become obsolete as technologies evolve. It is important for operators to choose a cabling strategy that is designed for today's needs as well as those of tomorrow. Solutions that offer high flexibility and modularization will play an important role in today's data center network architecture and beyond.

Density

Today, a 19-inch rack has an average power consumption of 6-8kWH, but it is predicted that in the future the power consumption could increase to 18-20kWH. This is a huge challenge for a data center where efficiency is key. Cooling must be optimized, air flow needs to be properly managed and the required processing power needs to be reduced with new technologies.

As upcoming technologies require not only more power but also more fibers, we see a trend towards smaller connectors, known as VSFF (very small form factor) and more fibers in the same cable, for example, ribbon solutions.

Deployment

Time is money and with data centers being built faster than ever before, it is important that the network can be deployed as quickly as possible. Fast deployment, both during construction and operation, is key to delivering world-class services to both internal and external customers. It is important to have a structured cabling strategy that allows for quick moves, adds and changes (MACs) during installation and operation.

Automation

As data center growth continues, more and more data centers are being built around the world. The shortage of skilled workers is already a fact that cannot be ignored. The naked truth is that data center operators will be challenged by the evolution of technology and operations.

A semi- or even fully-automated cabling infrastructure will not only improve your service level offerings, but also reduce the need for on-site staff. By implementing more automated systems you will improve both the total cost of ownership of your data network system and provide better services to your customers, whether internal or external.

Digitalization

Internet of Things, Industry 4.0, Machine-to-Machine learning – yes, digitalization is no longer just a buzzword and will inexorably find its way into your data center. By using these new technologies you can operate in a more efficient, secure and economical way. With the installation of all-optical switches, you can use Software Defined Networking (SDN) of the optical physical layer giving you full power of your automated data center infrastructure management (AIM/DCIM).

Speed, Speed, Speed

New virtual applications, software requirements and – not to neglected – changing human behaviour have forced today's network architecture to offer higher bandwidths. The trend towards more speed doesn't seem to be reaching its limits anytime soon. That means not only your active equipment must be ready to handle these new requirements but also your fiber infrastructure. Having an optical cabling structure in place which can cope with today's and tomorrow's transceivers you can seamlessly integrate 400GbE and beyond applications into your data center. Bandwidth expansion options using the same fiber layer (xWDM technology) can play a key role both inside and outside your data center.

Latency

Certainly, there are already business-critical applications today and there will be no fewer in the future. If you offer a network that enables low latency, you have many advantages. A combination of structured cabling, all-optical switching and bandwidth expansion opens new doors for data centers to, not only operate at lower latency, but also seamlessly integrate edge data centers into the network to further minimise latency.

HUBER+SUHNER AG
Degersheimerstrasse 14
9100 Herisau
Switzerland
Phone +41 71 353 41 11
hubersuhner.com

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