Fiber Optic Infrastructure Application Guide

Deploying Fiber Optic Infrastructure to Support Cisco Nexus Connectivity

Application Guide

March 2013

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About Corning Cable Systems

Corning Cable Systems, part of the Corning Incorporated telecommunications segment, is a leading manufacturer of fiber optic communications system solutions for voice, data, and video network applications worldwide. For more information, visit the website at http://www.corning.com/cablesystems.

Introduction

As data centers consolidate into more complex systems, they take advantage of new speed increases and technologies. The speed changes from 1- to 10-Gbps infrastructure were easy to understand. With speeds in the data center now increasing from 10 Gbps to 40 Gbps and eventually to 100 Gbps, different optical technologies and cabling infrastructures are required. This document introduces the cable requirements for 40-Gbps infrastructure and fundamental cabling principles supporting Cisco Nexus® 6000 Series Switches. Although alternative cabling options are mentioned (Twinax and active optical assemblies), the main focus of the document is cabling for pluggable optical Enhanced Quad Small Form-Factor Pluggable (QSFP+) modules.

The new Cisco Nexus 6000 Series provides high 10 and 40 Gigabit Ethernet density in energy-efficient switches with a compact form factor. With a robust integrated Layer 2 and 3 feature set, the Cisco Nexus 6000 Series provides a versatile platform that can be deployed in multiple scenarios - direct-attach 10- and 40-Gbps access and high-density fabric extender aggregation deployments, leaf-and-spine architecture, and compact aggregation solutions - to build scalable Cisco® Unified Fabric in the data center. Cisco Nexus 6000 Series-based architecture can adapt to increasing bandwidth demands with low power and a compact space profile, providing savings in capital expenditures (CapEx) and operating expenses (OpEx).

Structured (Some Permanent Links) or Unstructured System

When designing a networking system, it is important to plan the cabling system in advance. The goal is to address current network requirements as well as accommodate future growth.

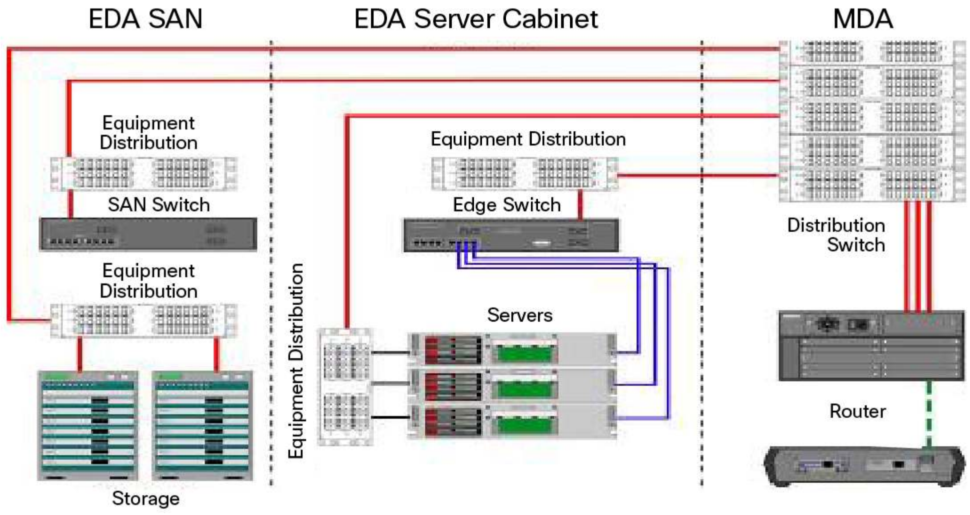
A structured cabling system provides a flexible cabling plan to address the commonly performed tasks of moving, adding, or changing the infrastructure as the network grows.

A good analogy in support of a structured cabling system is the electrical wiring in your home. When connecting appliances and devices, you require only a 5-foot connection to the closest electrical outlet. However, without an electrical outlet, all appliances would have to connect directly to the breaker or panel, requiring a cable of 200 feet or more. This approach would be inefficient and would become unmanageable as you add multiple appliances or devices throughout the home. The same concept applies to data centers, in which structured cabling becomes a necessity as the infrastructure grows and as constant moves and changes reinforce the need for a reliable network that is also easy to troubleshoot.

Structured cabling requires additional initial investment to create the cabling infrastructure, but the recurring benefits more than outweigh the slight additional incremental cost. Imagine the cost of deploying a two-fiber optical jumper each time a new server is placed in the data center. Further, regardless of whether the data center has a raised floor or uses overhead cabling, both result in time-consuming and inefficient deployment in an unstructured environment. Likewise, management of such an environment is cumbersome, increasing the risk of outages caused by human errors.

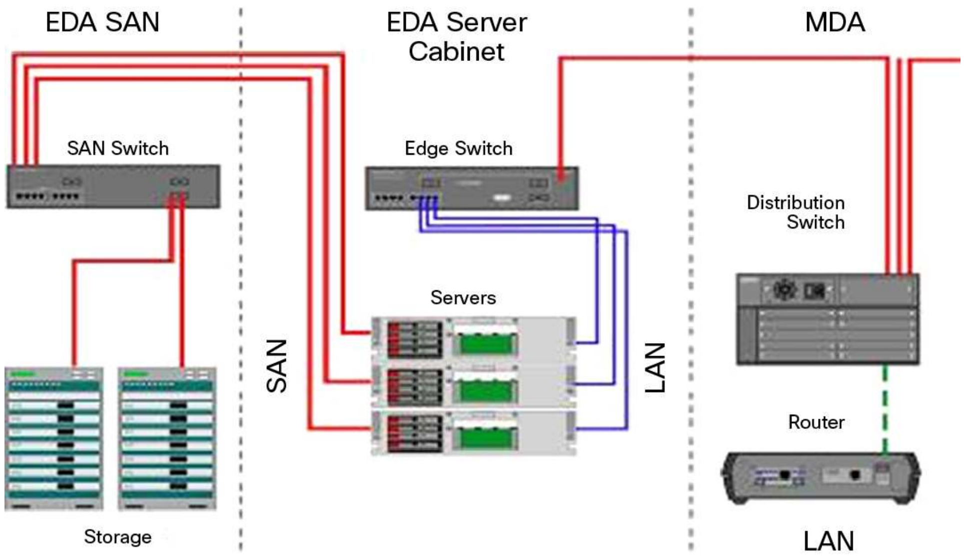
Structured cabling uses fiber termination connector panels that are connected through permanent links of optical cabling, typically configured in a star topology. All cabling in the data center server areas is consolidated in a central location near the core switch in the network (the core switch is analogous to the breaker or power panel in the home electrical system analogy). The permanent preterminated trunk cables branch to the zones in the data center, which contain servers, storage, or network devices. Note that with structured cabling, you still need some device-to-device connections at the access layer. As you can see in Figure 1, when making these short connections within the same cabinet or even a few cabinets away, the use of patch panels may not be required. Likewise, patch panels would not be required for Inter-Switch Link (ISL) connections.

Figure 1. Structured Cabling



Unstructured cabling occurs when optical links are deployed in a point-to-point or device-to-device design. In this situation, cabling pathways become congested with an entangled mess of two-fiber optical patch cords (Figure 2).

Figure 2. Unstructured Cabling



Types of Fiber Optic Fiber

As a result of the emergence of high-data-rate systems such as 10, 40, and 100 Gigabit Ethernet, laser-optimized multimode fiber has become the dominant fiber choice. These 50-micron fibers are optimized for the 850-nanometer (nm) transmission of vertical-cavity surface-emitting laser (VCSEL)-based transceivers. The TIA-492AAAC OM3 detailed fiber standard was released in March 2002, and the TIA-492AAAD OM4 detailed fiber standard was released in August 2009. Corning suggests installing either OM3 or OM4 cabling in the data center space based on length requirements. The two fibers have different bandwidths (information carrying capacity), which results in different achievable lengths for the same transceivers. Table 1 shows the achievable distances based on the OM3 and OM4 fibers at various data rates. TIA 942-A Telecommunication Infrastructure Standards for Data Centers only recognizes OM3 and OM4 multimode fiber type (it removed OM1, which was 62.5, and OM2, which was standard 50 micron). In addition, the standard provided further guidance to recommended OM4 cabling as a suggestion utilizing LC and MTP® connectivity.

Table 1. 850-nm Ethernet Distance (m)

	1-Gbps 1000BASE-SX	10-Gbps 10GBASE-SR	40-Gbps 40GBASE-SR4	40-Gbps 40GBASE-CSR4	100-Gbps 100GBASE-SR10
OM3 (50µm)	1000	300	100	300	100
OM4 (50µm)	1000	400	150	400	150

Types of Optical Transceiver Modules

The transceiver is an electronic device that receives an electrical signal, converts it into a light signal, and launches the signal into a fiber. It also receives the light signal and converts it into an electrical signal. For data rates =>1 Gbps, a multimode transceiver uses an 850-nm VCSEL transceiver. The 850-nm VCSEL transceiver provides the optimum technical and economic solution for high-bit-rate (=>1 Gbps) operation that makes 50-micron multimode fiber the most deployed optical fibers in the data center today.

SFP+ is the dominant transceiver form factor used for 1 and 10 Gigabit Ethernet applications. The transceiver uses an LC optical connector interface. For more information, see http://www.cisco.com/en/US/prod/collateral/modules/ps5455/data_sheet_c78-455693.html.

The QSFP+ transceiver is the dominant transceiver form factor used for 40 Gigabit Ethernet applications. The optical connector interface is a 12-fiber MTP® Connector. For more information, see http://www.cisco.com/en/US/prod/collateral/modules/ps5455/data_sheet_c78-660083.html.

Table 2 shows connectivity options and their advantages and disadvantages.

Table 2. Connectivity Options

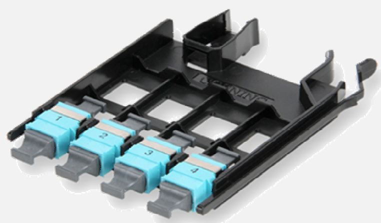
	Example	Advantages	Disadvantages
Pluggable optical modules	• QSFP-40G-SR4 • QSFP-40G-CSR4 • QSFP-40GE-LR4	Allows extended reach capabilities (400m on multimode fiber (MMF) and 10 km on single-mode fiber (SMF)); Cable links and optical engines are separate and thus can be upgraded independently	More expensive than other short-reach direct-attach options
Passive direct-attach copper	• QSFP-H40G-CU1M • QSFP-4SFP10G-CU1M	Allows lower-cost short-reach capability	Limited to less than 5m, and coaxial cable can be stiff and bulky in high-density deployments
Active direct-attach copper	• QSFP-H10G-ACU7M	Allows lower-cost short-reach capability	Limited to less than 10m, and coaxial cable can be stiff and bulky in high-density deployments
Active optical cable assemblies	• QSFP+-AOC (1/2/3/5/7/10m)	Allows lower-cost short-reach capability with more flexible cabling	Limited to less than 10m

Typical Optical Cabling Components

Table 3 shows typical cabling components.

Table 3. Typical Cabling Components

Component	Product Photo	Description
MTP® Trunk Cable		These fiber trunk cables are typically 12-144 fibers and create the permanent fiber links between patch panels in a structured environment. They are pre-terminated from the manufacturer with MTP Connectors at a specified length and have a pulling grip for easy installation.

Component	Product Photo	Description
Connector Housings		The connector housings are physically mounted in a 19” rack or cabinet. They are typically offered in various sizes such as 1U, 2U, or 4U which refers to the amount of rack space required for mounting.
MTP-LC Module		The MTP-LC module is installed into the connector housings. They breakout the MTP connections from the trunk cables, into LC connections for 1 and 10G applications. Thus, the trunk cables would plug into the rear MTP of the module, while the LC jumpers would plug into the front of the module.
MTP Connector Panel		The MTP-MTP Connector panel (sometimes called bulkhead) is installed into the housings. They offer a connection point between the MTP trunk and MTP jumper for 40 and 100G applications. Thus, the trunk cables would plug into the rear of the panel, while the MTP jumpers would plug into the front of the panel.
MTP-LC Harness (breakout cable)		The MTP-LC harness assembly is used for breaking out the MTP into several LC connections. One application is to connect the MTP trunk cables into multiple 1/10G switch ports. Another application could be connecting two network devices directly. For example, connecting a TOR switch with (4) 10G uplinks into a single 40G port on the aggregation switch.
LC or MTP Jumpers		The LC or MTP jumpers serve to create the connection between the device port sand the structured cabling via the connector panel.

For more detailed information about these products please visit: http://cablesystems.corning.com/1-NX6Cabling.

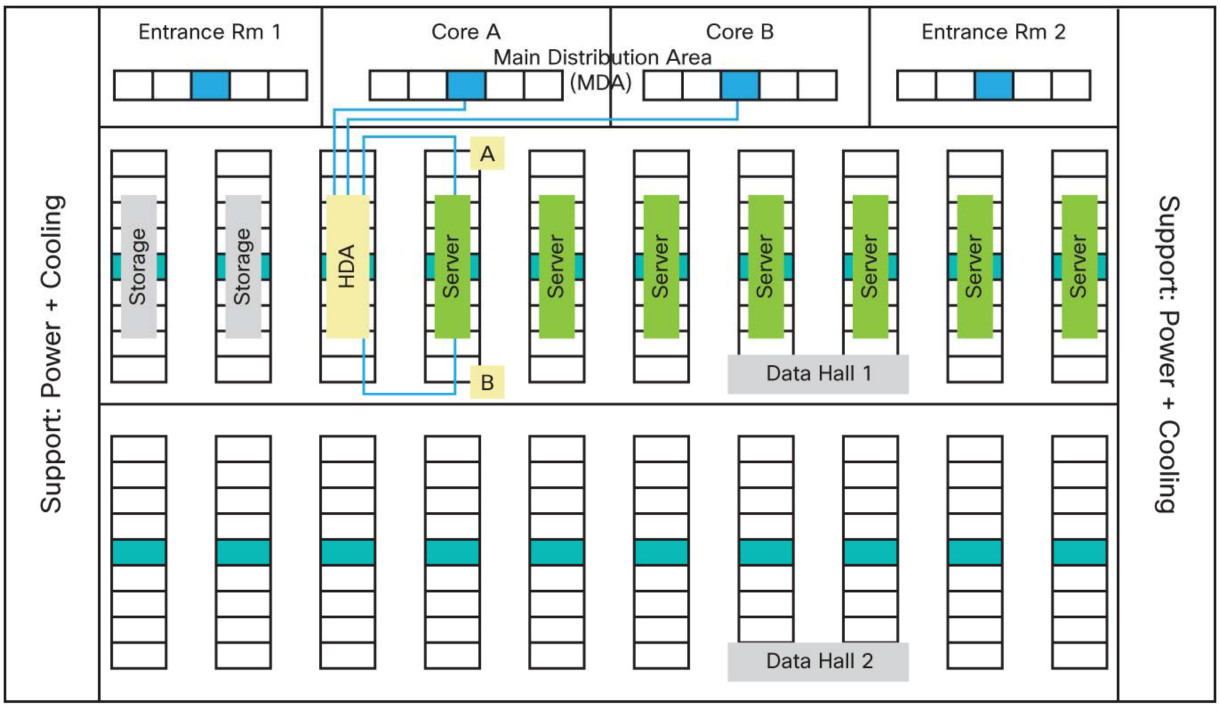
Cisco Nexus 6000 Series Connection

This section presents a sample customer data center deployment and shows how the products and the structured cabling are deployed. This example examines some typical optical connectivity links in a large-scale fabric and looks specifically at the data center environment, but the same connectivity can apply to a consolidated campus and data center core or commercial fabric.

In general, a data center has two points-of-presence (POP) rooms; this is where the campus or carrier demarcation occurs. Optical cabling connects each entrance room to each main distribution area (MDA). The MDA is cabled to the horizontal distribution area (HDA) in each data hall (or point of distribution [POD]). The HDA, also known as the aggregation point, then fans out to each equipment distribution area (EDA) for direct server or storage connectivity. The HDA typically is the end-of-row (EoR) or middle-of-row (MoR) network equipment rack. The EDA typically is the ToR patch panel or a ToR networking device such as a Cisco Nexus 5500 switching platform or Cisco Nexus 2000 Series Fabric Extender.

These are the various physical areas of the data center space; next consider the placement of network equipment. Figure 3 shows a typical placement of the network equipment in the physical areas. In addition, it shows the typical cabling connectivity between the networking devices.

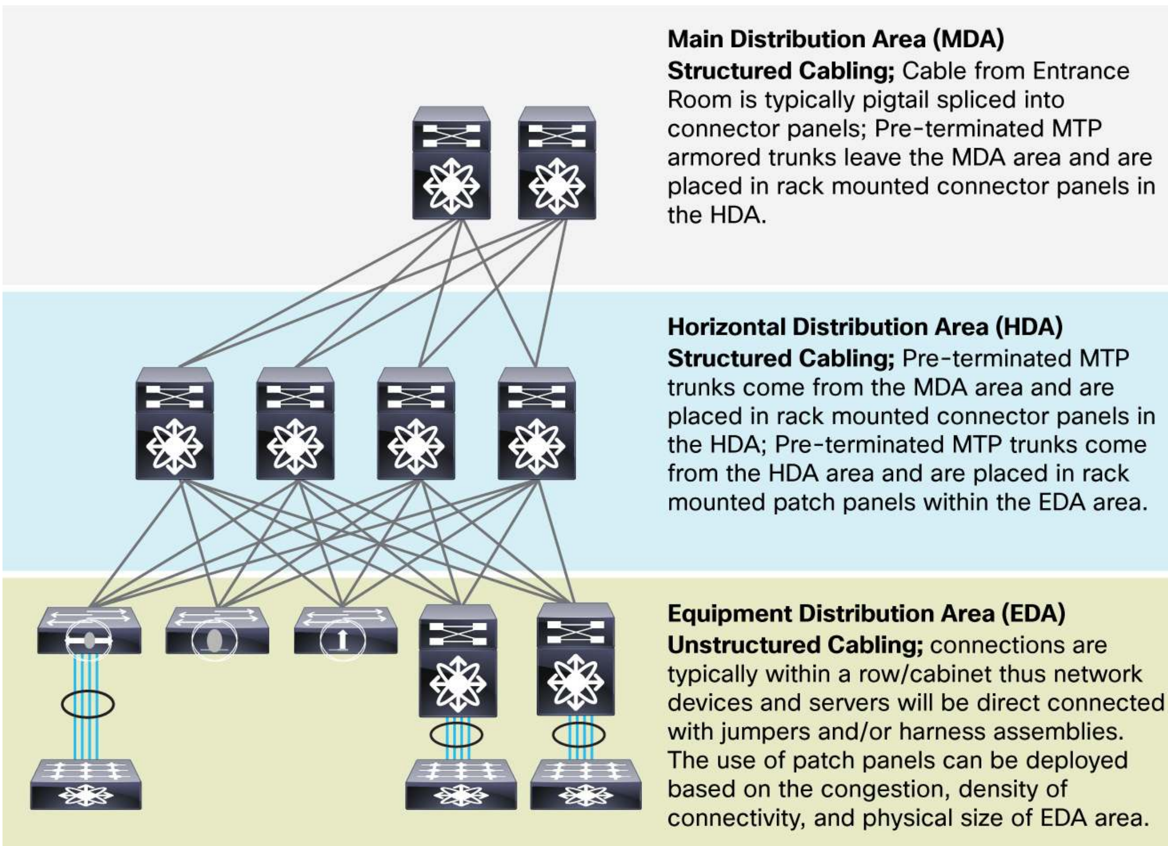
Figure 3. Physical Data Center Floor Layout



MDA-to-HDA Connectivity

When cabling between the MDA and the HDA (Figure 4), some cabling considerations depend on the layout of the data center. This structured cabling trunk typically is a high-fiber-count (>48 fibers) MTP trunk cable. If the cable runs in high-traffic areas with pathways shared with other mechanical support systems, an interlocking armored cable often is selected. The additional crush protection reduces the risk from accidental damage. In addition, depending on the size of the data center, the distance may require single-mode cabling for the additional distance support. The pathway from the MDA to the HDA typically is the longest internal data center link in the system.

Figure 4. Logical Connectivity of Cisco Nexus 6000 Series Switches



Another consideration is the flexibility associated with a cross-connect, also referred to as a patch-panel field. This port-level patching location (outlined with a dotted line in Figure 5) allows connectivity between any port and any other port in an organized way. The flexibility created by this central patching field guarantees the ability to achieve any desired link configuration. The cross-connection allows:

- Meshing of switch ports
- Segregation of business units (which may have different maintenance schedules)
- Clean mixing of 10 to 10-Gbps and 10 to 40-Gbps links

Figure 5. 10-Gbps Connectivity with SFP Port Replication (Cross-Connect)

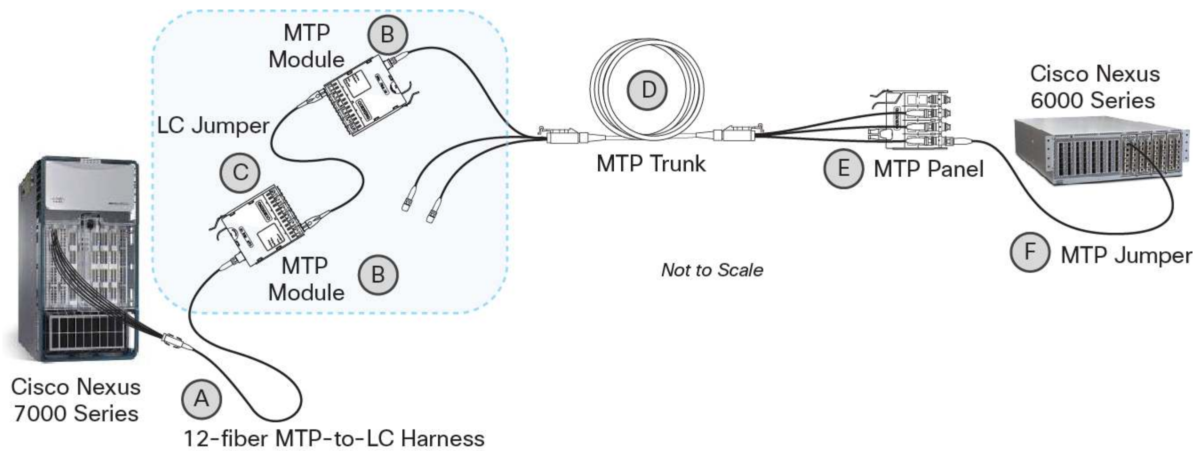
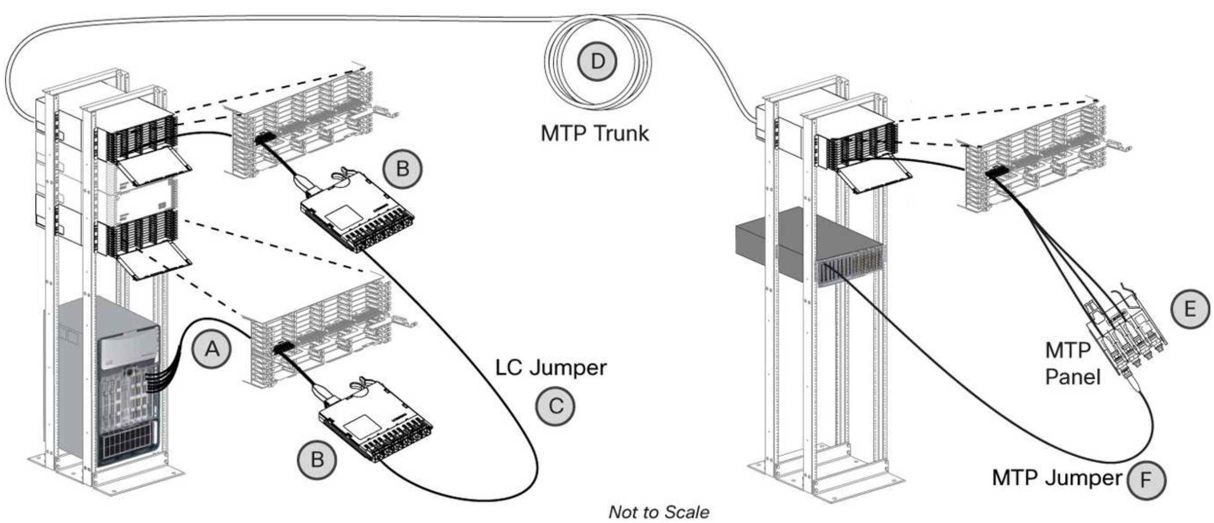


Figure 6. Physical Rack Layout of 10-Gbps Connectivity with SFP Port Replication



The MDA or network core is connected to the HDA or network aggregation layer. A typical network core may be composed of Cisco Nexus 7000 Series devices, and the aggregation layer may consist of a Cisco Nexus 6004 Switch. When the Cisco Nexus 6004 is used as an aggregation device with connectivity to a core such a Cisco Nexus 7000 Series Switch through a structured cabling infrastructure, the device may be part of either a 10- or 40-Gbps fabric.

In a 10-Gbps fabric deployment with the Cisco Nexus 7000 Series, simplification of cabling to the Cisco Nexus 6004 is possible using MTP®-terminated trunk cables. Permanent structured cabling links would be deployed using these MTP-based trunks to create connector patching fields at each end. Then short MTP or LC jumper patch cables would be used to make the connection from the patch field to the QSFP+ or SFP+ optics at the switch port. The MTP patch-panel field allows the end device to be connected to any port across multiple Cisco Nexus 6004 devices because the devices terminate at the patch-panel field.

In the future, when the core is upgraded to support QSFP+ optics and 40-Gbps flows, the existing structured cabling infrastructure can be maintained, and only the harness assembly (J) that terminated in the LC-based Cisco Nexus 7000 Series I/O module need to be replaced. The rest of the infrastructure from the Cisco Nexus 6000 Series Switch through the patch-panel field would remain the same for 40-Gbps flows.

Some links may not require the flexibility of having a cross-connect, and in this case, a direct interconnect would be deployed. In this situation, the structured cabling (MTP trunk) would still be terminated in rack-mounted patching panels at the network devices; then there is an interconnect using a jumper from the patch field directly to the device. Figure 7 shows a 10-Gbps interconnect link between a Cisco Nexus 7000 Series Switch and a Cisco Nexus 6000 Series Switch.

Figure 7. 10-Gbps Connectivity with Interconnect

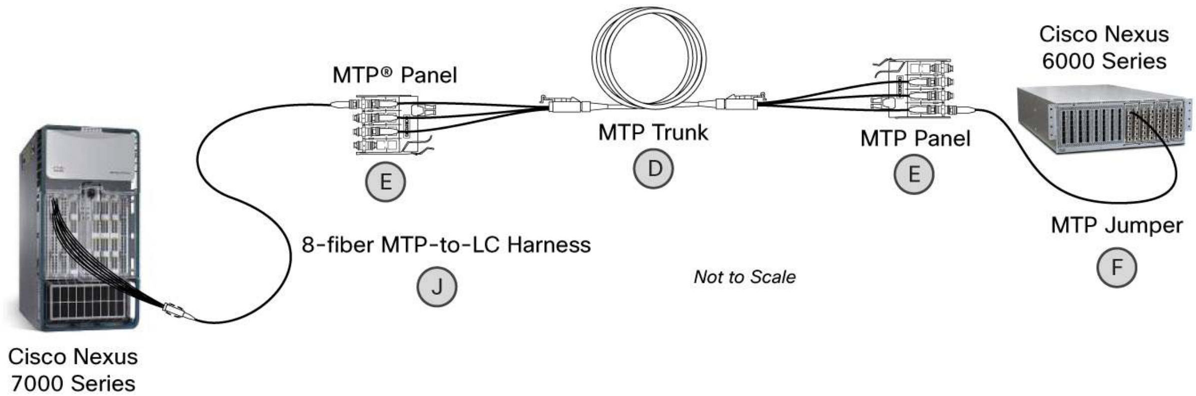


Figure 8 shows an alternative connectivity scheme for a 10-Gbps flow between the Cisco Nexus 7000 Series and the Cisco Nexus 6004. This scheme uses an MTP module with LC jumpers, instead of the eight-fiber harness assembly shown in Figure 7. This approach provides more flexibility when patching at the SFP+ connections, especially when patching between port groups or across blades.

Figure 8. 10-Gbps Connectivity with Interconnect Using Modules and LC Jumpers

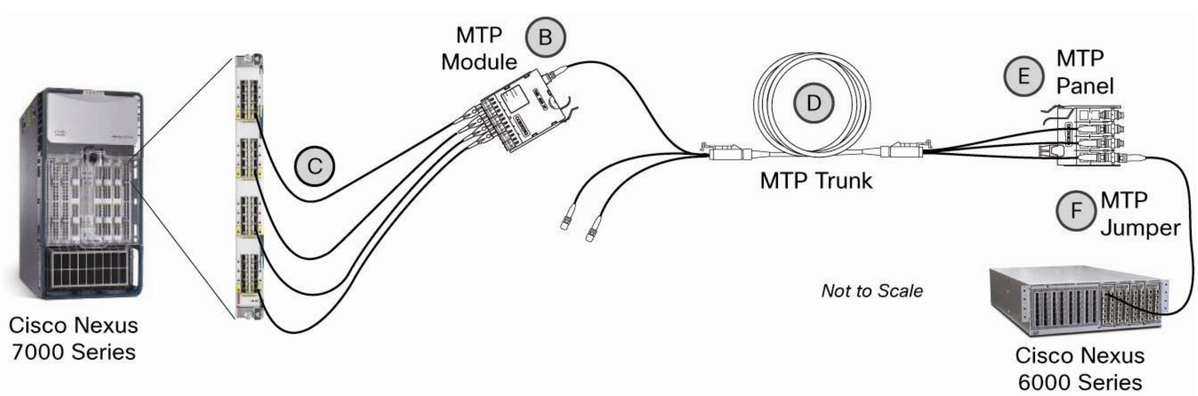


Table 4 shows a sample bill of materials for the MDA-to-HDA connectivity shown in Figures 5 through 8.

Table 4. Sample Bill of Materials

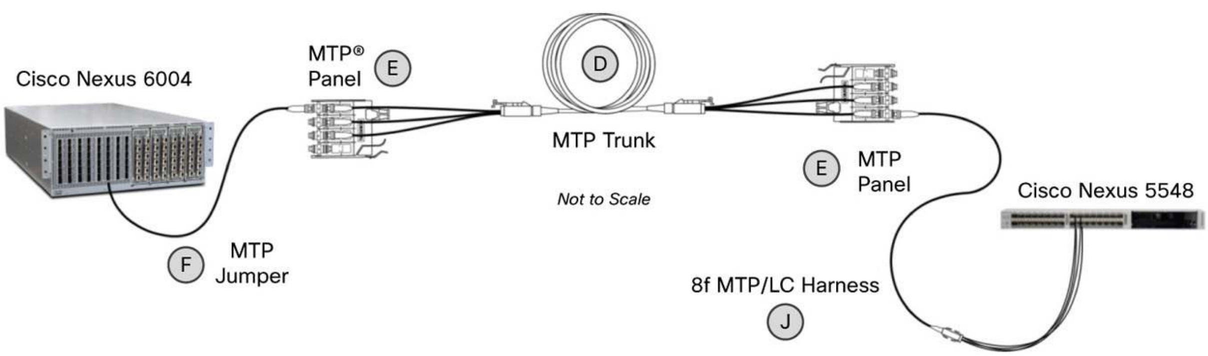
Corning Part Numbers

Identifier	Part Number	Description
A	H757912TPH-3W010F	MTP®(pinless) to LC Uniboot harness breakout cable for Nexus 7000; 10F length
B	ECM-UM12-05-93T	12-fiber LC Duplex to MTP(pinned)
C	797902TD120002M	LC Uniboot Jumper; 2m
D	G7575E4TPNDDU100F	144-fiber MTP Trunk Cable; 100ft
E	EDGE-CP48-E3	48-fiber (4-port) MTP Adapter Panel
F	J937512TE8-NB010F	MTP(pinned) to MTP(pinless) OM3 jumper; Type-B polarity; 10ft
J	H937908QPH-KZU010F	8-fiber harness; MTP(pinned) - (4) LC Uniboot; OM3/4 50/125; 24” LC breakout and overall length of 10ft
K	EDGE-04U	EDGE 4U 19” Rack mount housing; holds 48 EDGE modules or panels

HDA-to-EDA Connectivity

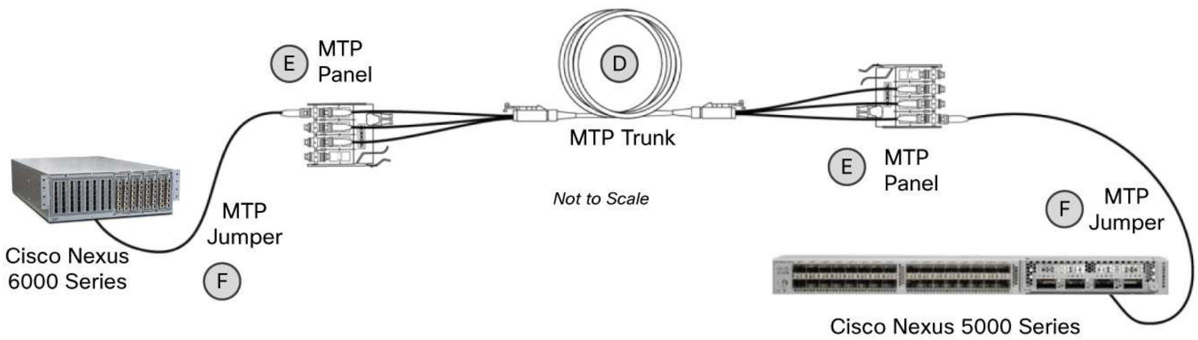
Most network endpoints will be either 1- or 10-Gbps devices, so minor cabling changes are needed to support 10-Gbps devices such as the Cisco Nexus 5548. Figure 9 shows a Cisco Nexus 6004 that is connected to the base ports of a Cisco Nexus 5500 platform switch. These endpoint connections will be MTP and LC, respectively, and the structured cabling infrastructure maintains MTP trunks and panels. This approach will require a MTP-to-LC harness assembly to make the connection from the termination patch field to the Cisco Nexus 5500 platform. A MPO jumper can be used to make the connection from the termination patch field to the Cisco Nexus 6004.

Figure 9. 10-Gbps Connectivity with Interconnect (MTP to LC)



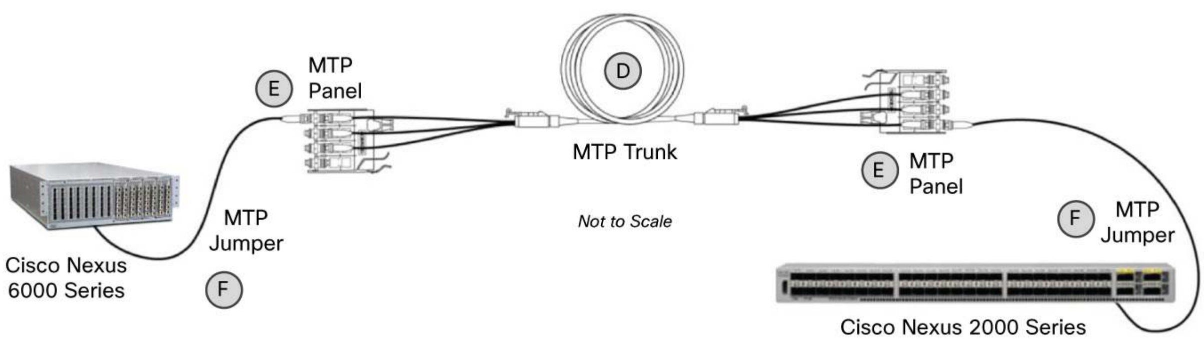
If the Cisco Nexus 5500 platform switch has an MTP®-based module (N55-M4Q) installed, then the MTP-to-MTP patch cable can be used. Deployments of this type could be used in places in which the Cisco Nexus 5500 platform is a ToR switch or a fabric extender aggregator. In both cases, the Cisco Nexus 6004 is used as an aggregation point for the network edge, as shown in Figure 10.

Figure 10. 10-Gbps Connectivity use QSFP+ and MTP Interconnect



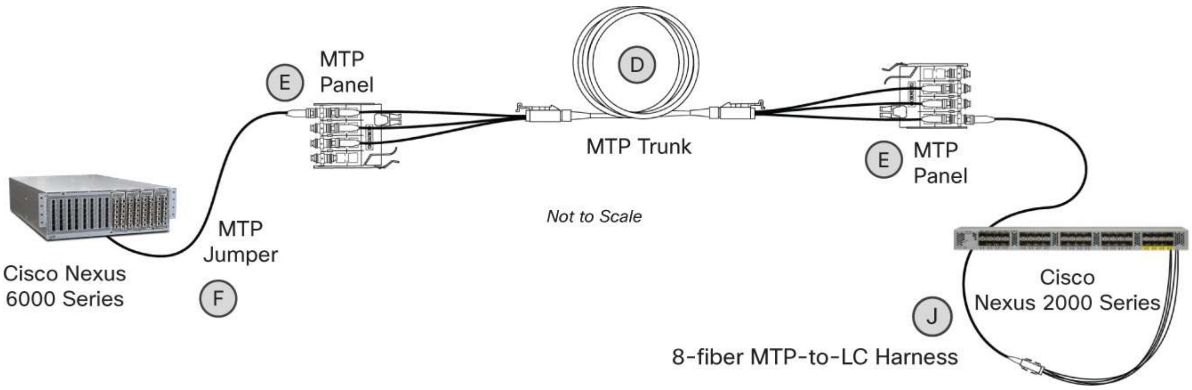
The Cisco Nexus 6004 has enormous deployment flexibility and can also be used as a fabric extender aggregator in EoR or MoR deployments or as an uplink aggregation device. In these deployments, the ports on the Cisco Nexus 6004 simplify cabling through the use of MTP optic cabling end to end, and the switch supports 40-Gbps flows for the future (Figure 11).

Figure 11. 10G Connectivity with QSFP+ and MTP interconnects



When structured cabling is used, the end device patch cords (F or J) are chosen to match the device: either MTP® or LC. The other end of the cable will be an MTP cable that connects to an MTP adapter panel that is installed in an adapter panel carrier. Connectivity between the two adapter panels is achieved with high-fiber-count MTP trunk cables (D). These trunks allow fast connection of large fiber counts quickly and effortlessly (Figure 12).

Figure 12. 10G Connectivity mixed MTP and LC interconnects



In all these connections, the Cisco Nexus 6004 is used to connect to a 10-Gbps switch such as the Cisco Nexus 5500 platform or a fabric extender, and the ports on the Cisco Nexus 6004 will be configured in 10 Gigabit Ethernet mode to match those of the Cisco Nexus 5500 platform.

The Cisco Nexus 6004 is a high-density 10- and 40-Gbps switch. It can be an EoR or MoR device, too. In that case, the Cisco Nexus 6004 can be used in both the aggregation and access layers. This configuration takes advantage of the MTP cabling and also allows full support of 40-Gbps flows between the devices. Figure 13 shows the cabling between two Cisco Nexus 6004 Switches.

Figure 13. 40G Connectivity with Interconnect

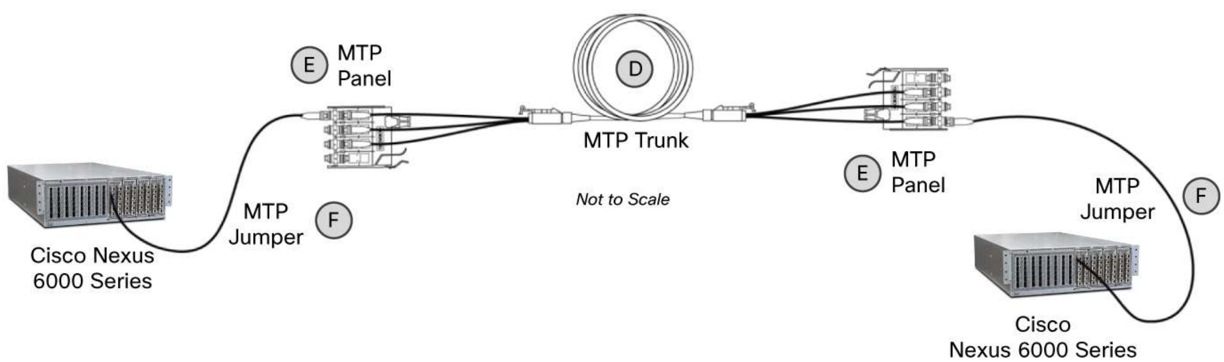


Figure 14 shows how a Nexus 6004 would be connected to multiple Nexus 6001 switches. Here a structured cabling trunk is used to connect these devices which could be hundreds of feet apart in separate rows of cabinets.

Figure 14. 40G Connectivity with Interconnect

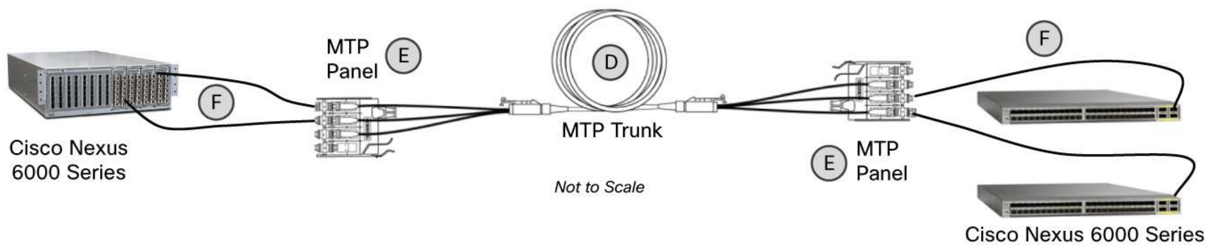


Table 5 shows a sample bill of materials for the HDA-to-EDA connectivity shown in Figures 9 through 14.

Table 5. Sample Bill of Materials

Identifier	Part Number	Description
D	G7575E4TPNDDU100F	144-fiber MTP® trunk cable; 100 ft
E	EDGE-CP48-E3	48-fiber (4-port) MTP adapter panel
F	J937512TE8-NB010F	MTP (pinned) to MTP (pinless) OM3 jumper; Type-B polarity; 10 ft
G	H757908QPH-KW010F	8-fiber harness; MTP (F) to (4) LC uniboot; OM3/4 and 50/125; 24-in. LC breakout and overall length of 10 ft
J	H937908QPH-KU010F	8-fiber harness; MTP (pinned) - (4) LC Uniboot; OM3/4 50/125; 24" LC breakout and overall length of 10ft

EDA Connectivity

The equipment distribution area, or EDA, is the row of computing cabinets; this is where the servers, storage, and other devices reside. The EDA is the access edge of the network. Here you will typically find a variety of devices, including the Cisco Nexus 5500 platform, Cisco Nexus 2000 Series fabric extenders, and Cisco Nexus 6001. The Cisco Nexus 5500 platform and the Cisco Nexus 6001 can be used as ToR devices. They can also be used with the Cisco Nexus 2000 Series Fabric Extenders to connect a greater number of servers.

Because the access edge is typically confined to a row of racks, structured cabling can be used, and device direct connections are possible. If structured cabling to each server rack is used, then the infrastructure will be similar to that depicted earlier. If a direct-connect scheme is used, then there would be no connector patch panels placed in the link from the device port to the device. In this case, a single fiber optic cabling assembly is used to make port-by-port connections. Figures 15 and 16 show connectivity to ToR devices, while figure 17 shows the physical layout of the equipment in a cabinet. In this diagram one can imagine the Cisco Nexus 6004 being located in a cabinet as an aggregation point for which many servers cabinets containing the Cisco Nexus 6001.

Figure 15. 10-Gbps Connectivity with Interconnect Structured Cabling

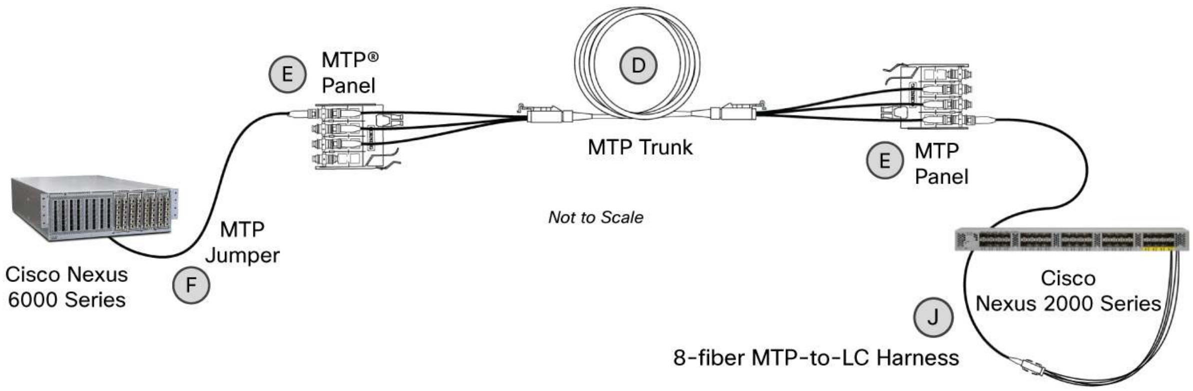


Figure 16. 10-Gbps Connectivity with Interconnect Structured Cabling

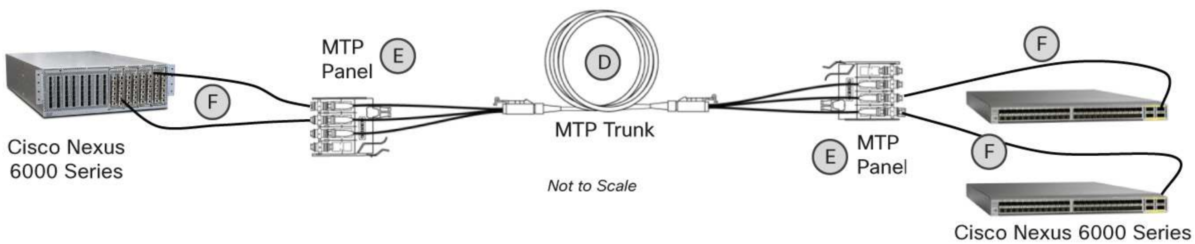
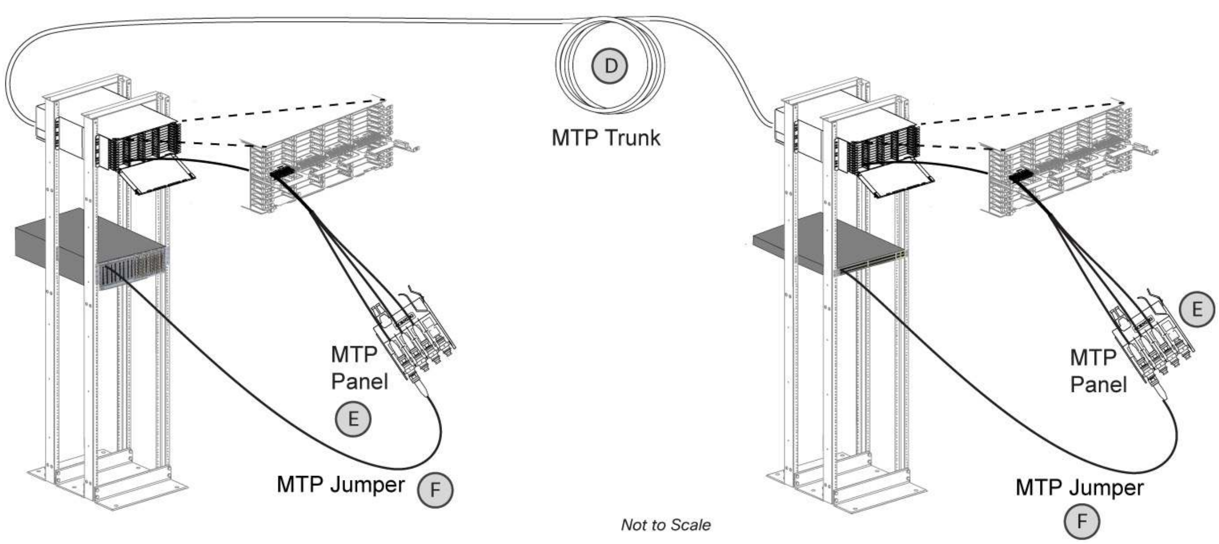


Figure 17. Physical rack layout of 40G connectivity from Nexus 6004 aggregation switch to Nexus 6001 top of rack switch in server cabinet (for simplicity only one server rack is shown)



If structured cabling patch panels are not used at each computer rack, then the ToR switch (Cisco Nexus 5548P or UP Switch or Cisco Nexus 6001) or a fabric extender can be directly connected with a patch cord jumper running down the row. Figure 18 shows a Cisco Nexus 6004 to a Cisco Nexus 2248PQ Fabric Extender. This could be deployed to connect many fabric extenders within the server row to a single Nexus 6004 aggregating switch placed within that row. Again, since patch cord jumper cables (MTP® and LC jumpers) can quickly become difficult to manage and are less robust, a direct connection is only suggested within the cabinet or server row. The MTP patch cord for direct connection requires a Type-B polarity with both MTP being a pinless style connector. More details on this jumper can be found in Appendix C.

Figure 18. 10-Gbps to 10-Gbps Connectivity: Direct Connect

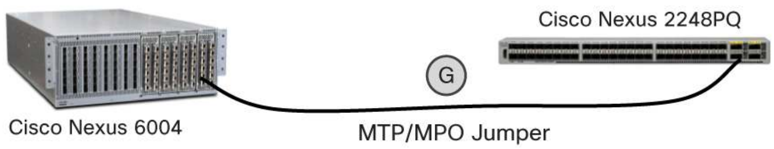


Figure 19 shows a Nexus 6004 connected to a Nexus 2000 series fabric extender that has LC connections. The Nexus 6004 can also support fabric extenders which have 10G upstream connectivity using an 8 fiber harness assembly. The polarity of this assembly allows correct pairing of the channels. More detail about this assembly can be found in Appendix B.

Figure 19. Nexus 60004 connected to a fabric extender using a fiber harness cable

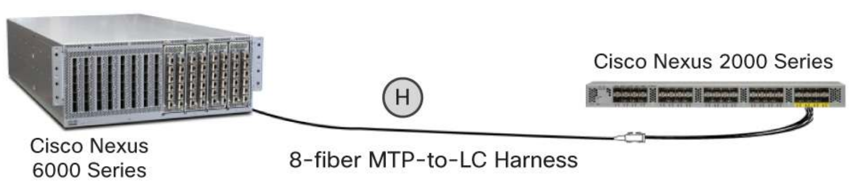
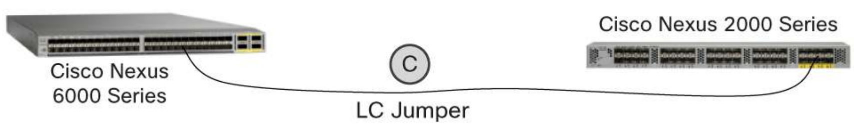


Figure 20 shows the Nexus 6001 connected to a Nexus 2000 series fabric extender. In this case, since both the Nexus 6001 and Nexus 2232PP have SFP ports which support LC based optical transceiver modules, we use a LC jumper.

Figure 20. 10G to 10G Connectivity - Direct Connect



For cases in which the ToR local switch is desired, a Cisco Nexus 5500 platform or Cisco Nexus 6001 can be used. This cabling is depicted in Figures 21 and 22. Figure 21 shows a Nexus 5548 with a QSFP+ GEM installed in expansion bay, thus an MTP jumper is used for direct connection between the device ports. Likewise, Figure 22 shows the Nexus 6001 being utilized as a top of rack local switch with QSFP+ links between the two device ports.

Figure 21. 10-Gbps Connectivity with Direct Connection

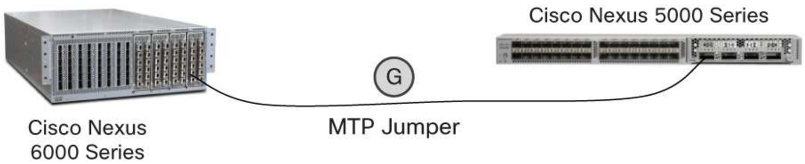


Figure 22. 40-Gbps Connectivity with Direction Connection

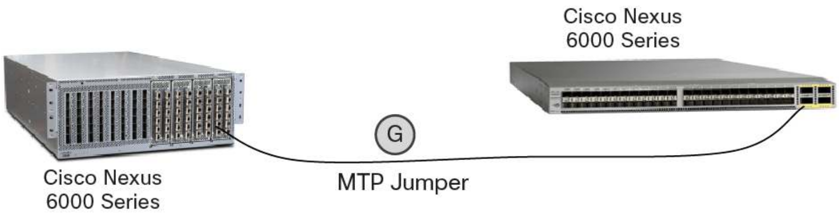


Table 6 shows the bill of materials for the EDA connectivity shown in Figures 15 through 22.

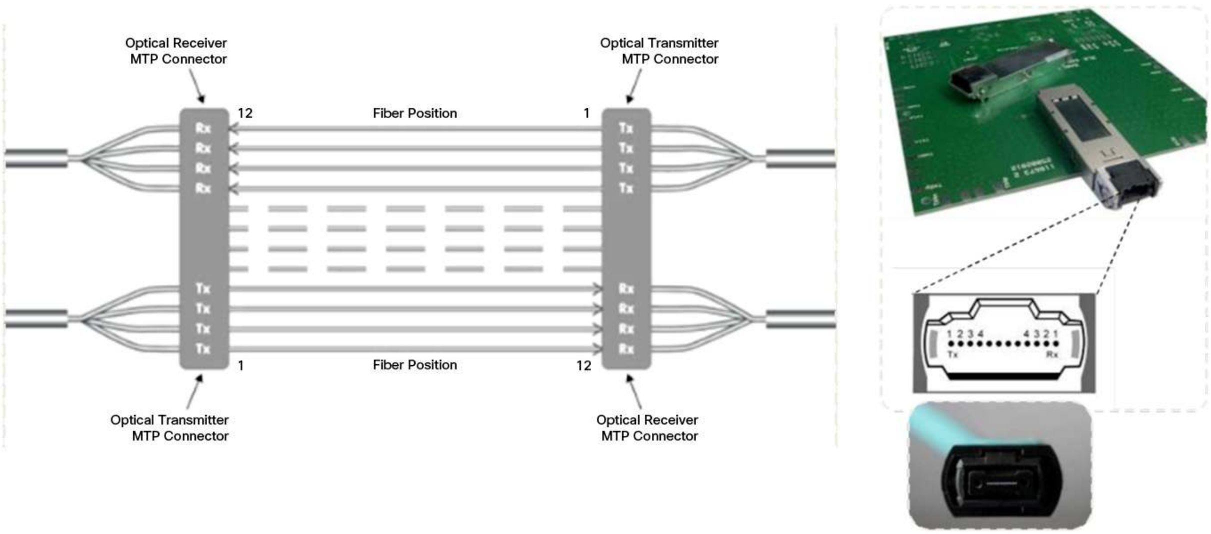
Table 6. Sample Bill of Materials

Identifier	Part Number	Description
C	797902TD120002M	LC Uniboot Jumper; 2m
D	G7575E4TPNDDU100F	144-fiber MTP® Trunk Cable; 100ft
E	EDGE-CP48-E3	48-fiber (4-port) MTP Adapter Panel
F	J937512TE8-NB010F	MTP(pinned) to MTP(pinless) OM3 jumper; Type-B polarity; 10ft
G	J757512TE8-NB010F (Details in Appendix C)	MTP(pinless) to MTP(pinless) OM3 jumper; Type-B polarity; 10ft
H	H757908QPH-KW010F (Details in Appendix B)	8-fiber harness; MTP(pinless) - (4) LC Uniboot; OM3/4 50/125; 24” LC breakout and overall length of 10ft
J	H937908QPH-KZ010F	8-fiber harness; MTP(pinned) - (4) LC Uniboot; OM3/4 50/125; 24” LC breakout and overall length of 10ft
K	EDGE-04U	EDGE 4U 19” Rack mount housing; holds 48 EDGE modules or panels

Fiber Utilization Concerns with 40-Gbps Cabling

Traditionally, optical-based Ethernet physical media required a duplex fiber scheme and thus required only two fibers. However, at data rates of 40 Gbps and higher, multimode cabling uses parallel optics instead of serial transmission. Thus, by combining multiple channels, each running a given data rate (typically 10 or 25 Gbps today), the desired data rate can be achieved. This approach requires more physical cabling per link than the traditional serial duplex links. The industry standard for structured cabling uses 12-fiber MTP trunk cables. The 40GBASE-SR Physical Media Dependent (PMD uses this same 12-fiber MTP connector, but it populates only 8 of the fiber positions (4 outer transmit and 4 outer receive fibers): hence, the dilemma about fiber utilization (Figure 23).

Figure 23. 40GBase-SR Lane Assignments



There are several basic cabling options for 40-Gbps connectivity. One approach is to ignore the unused fibers and continue to deploy 12-fiber MTP® cable assemblies. Another approach is to use a conversion device to convert two 12-fiber links into three 8-fiber links. Three solutions exist (summarized in Table 7 and Figure 24).

Solution 1: The no-conversion scenario, creates an additional cost of 33 percent more cabling plant, which is not used to transport any data.

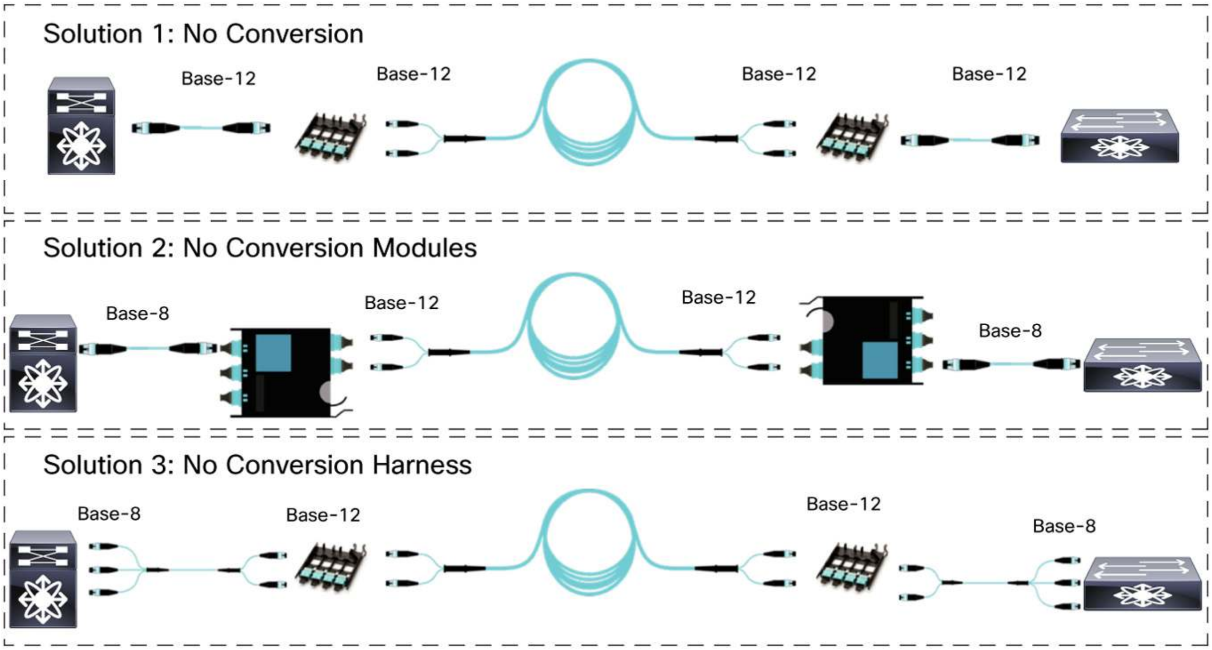
Solution 2: Uses conversion module patch panels to utilize the unused fiber. This solution has the additional cost of MTP connectivity to move the fiber strands to the correct positions; thus for every two 12-fiber MTP connectors, you can achieve three 8-fiber links. The cost of the additional MTP connectivity is offset by the cost savings of 100 percent utilization of the cable plant. At shorter lengths, where the amount of unused fiber is small, it is more cost effective to consider no conversion. However, at longer lengths, a conversion module system provides a cost savings because the overall length of unused fiber has increased.

Solution 3: This uses standard MTP bulkhead adapter panels, with a conversion assembly (two 12-fiber MPOs on one end going to three 8-fiber MTPs on the other end). This approach does not add any connectivity, and it achieves full fiber utilization. However, although this approach may appear to be the best, it involves considerable cabling challenges. For example, if you need only two 40-Gbps connections to a piece of equipment, what do you do with that third 8-fiber MTP? What if the 40-Gbps ports are in different chassis blades or completely different chassis switches? The result will be long breakout assemblies, which will be difficult to manage in an organized way. For this reason, Solution 3 is expected to be the least desirable and so least deployed method.

Table 7. Three Cabling Solutions for 40-Gbps Connectivity

	Description	Advantage	Disadvantage
Solution 1: **No conversion**	Uses traditional 120 fiber MTP connectivity and ignores unused fiber	Simplicity and lowest overall link attenuation	Does not use 33% of installed fiber
Solution 2: **Conversion module**	Converts two 12-fiber links to three 8-fiber links through a conversion patch panel	Uses all backbone fiber	Additional connectivity cost associated with conversion device
Solution 3: **Conversion assembly**	Converts two 12-fiber links to three 8-fiber links through a conversion assembly and standard panels	Uses all backbone fiber	Can lead to unorganized patch fields as a result of dangling connectors and non-optimized lengths

Figure 24. Three Cabling Solutions for 40-Gbps Connectivity



Corning Cable Systems offers components to build all three solutions. Please refer to the following link for additional information about the Corning Pretium EDGE®: http://cablesystems.corning.com/1-NX6Cabling.

Conclusion

Structured cabling using an MTP® cabling infrastructure can be used with current 10-Gbps environments while maintaining investment protection for 40-Gbps environments in the future. The permanent MTP based trunk cables remain unchanged during the conversion, with only minor changes at the connector patch panel, allowing a transparent transition. New data center switching platforms, such as the Cisco Nexus 6000 Series, are now using the cost-effective, lower-power optics at 40 Gbps to deploy innovative and flexible networking solutions. These solutions allow easy integration into existing environments and deployment of new options regardless of your zone (EoR or MoR) or ToR deployment needs.

Appendix A: Bills of Materials

Table 8. Cisco Part Numbers ID

Part Number	Image	Description
QSFP-H40G		QSFP+ Twinax cables

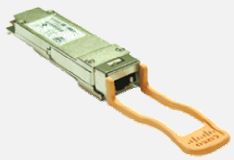
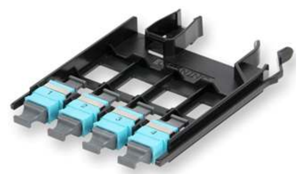
Part Number	Image	Description
QSFP-4x10G		QSFP+ to 4 10GBASE-CU SFP+ Twinax cables
QSFP-40G-SR4		QSFP+ SR4 optics
QSFP-40G-CSR4		QSFP+ CSR4 optics
GLC-SX-MM **SFP-GE-S** **GLC-SX-MMD**		SFP+ SR optics

Table 9. Corning Part Numbers

Identifier	Part Number	Image	Description
A	H757912TPH-3W010F		MTP® (pinless) to LC Uniboot harness breakout cable for Nexus 7K; 10F length
B	ECM-UM12-05-93T		12-fiber LC Duplex to MTP (pinned)
C	797902TD120002M		LC Uniboot Jumper; 2m

Identifier	Part Number	Image	Description
D	G7575E4TPNDDU100F		144-fiber MTP® OM3 Type-B Trunk Cable; 100ft
E	EDGE-CP48-E3		48-fiber (4-port) MTP Adapter Panel
F	J937512TE8-NB010F		MTP (pinned) to MTP (pinless) OM3 jumper; Type-B polarity; 10ft
G	J757512TE8-NB010F (Details in Appendix C)		MTP (pinless) to MTP (pinless) OM3 jumper; Type-B polarity; 10ft
H	H757908QPH-KW010F (Details in Appendix B)		8-fiber harness; MTP(pinless) - (4) LC Uniboot; OM3/4 50/125; 24" LC breakout and overall length of 10ft
J	H937908QPH-KZ010F		8-fiber harness; MTP(pinned) - (4) LC Uniboot; OM3/4 50/125; 24" LC breakout and overall length of 10ft
K	EDGE-04U		EDGE 4U 19" Rack mount housing; holds 48 EDGE modules or panels

Learn more about each of these products at: http://www.corning.com/i-Nx6Cabling.

Appendix B: Eight-Fiber MTP®-LC Assembly

The eight-fiber assembly uses a pinless MTP® connector on one end for interfacing with the QSFP port on the switch (referenced in this document as product H). The other end contains four LC uniboot connectors, which provide connectivity to the SFP+ ports on the switch. The polarity of the assembly pairs the fibers from the MTP Connector from the outside to the inside; thus, fiber 1 and fiber 12 are a duplex pair, as are fiber 2 and fiber 11, etc. Figure 25 shows the assembly, and Table 10 provides part numbers.

Figure 25. Eight-Fiber MTP-LC Assembly

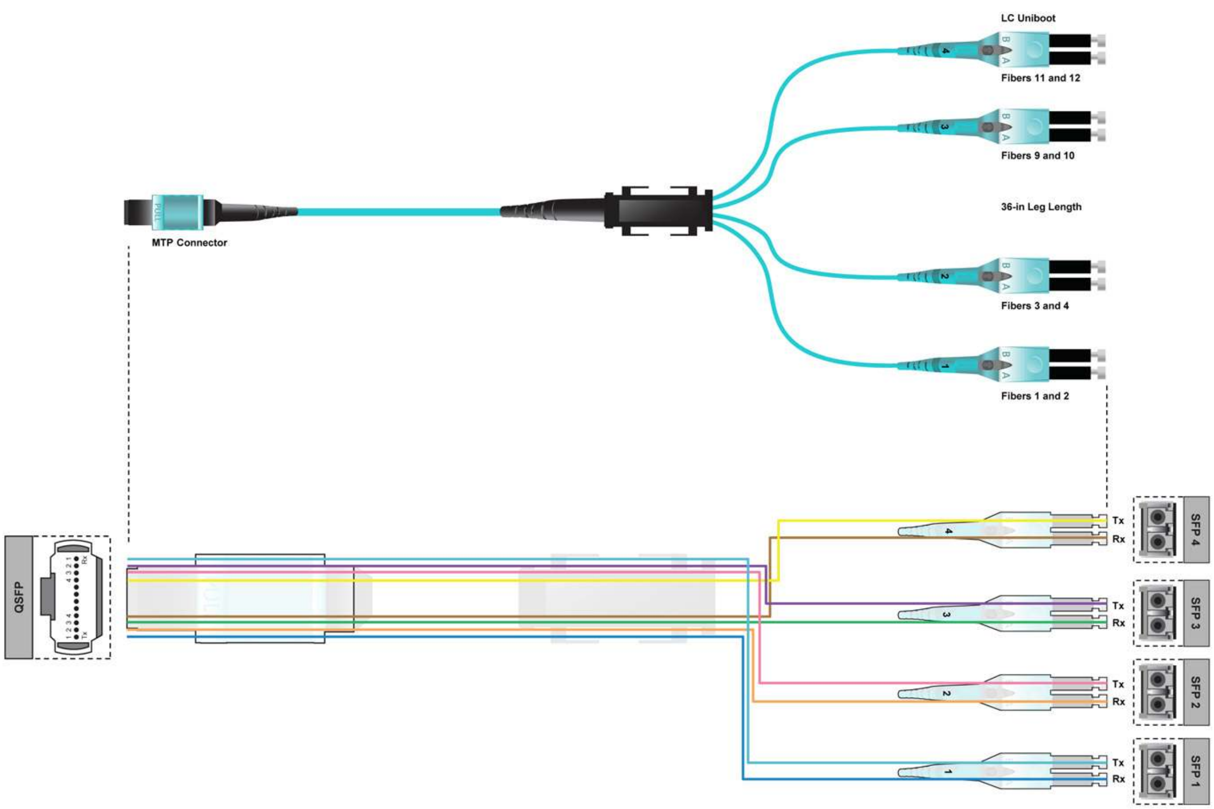


Table 10. Part Numbers

Corning Part Number	Description
H757908QPH-KW010F	8-fiber harness; MTP (F) to (4) LC uniboot; OM3/4 and 50/125; 24-in. LC breakout and overall length of 10 ft
H757908QPH-KW020F	8-fiber harness; MTP (F) to (4) LC uniboot; OM3/4 and 50/125; 24-in. LC breakout and overall length of 20 ft
H757908QPH-KW030F	8-fiber harness; MTP (F) to (4) LC uniboot; OM3/4 and 50/125; 24-in. LC breakout and overall length of 30 ft

Appendix C: Twelve-Fiber MTP-MTP Assembly

The 12-fiber assembly uses a pinless MTP connector on both ends to interface with the QSFP switch ports (reference in this document as product G). The polarity of the assembly complies with a TIA/EIA 568C.3 Type-B array patch cord. This standard states that ribbon fiber must be installed in consecutive order on one end, and installed in reverse consecutive order on the other end of the assembly. In other words, fiber 1 (blue fiber) is installed in position 1 on one end and in position 12 on the other end. This positioning is required for transmission and reception. Figure 26 shows this assembly, and Table 11 provides part numbers.

Figure 26. Twelve-Fiber MTP®-MTP Assembly

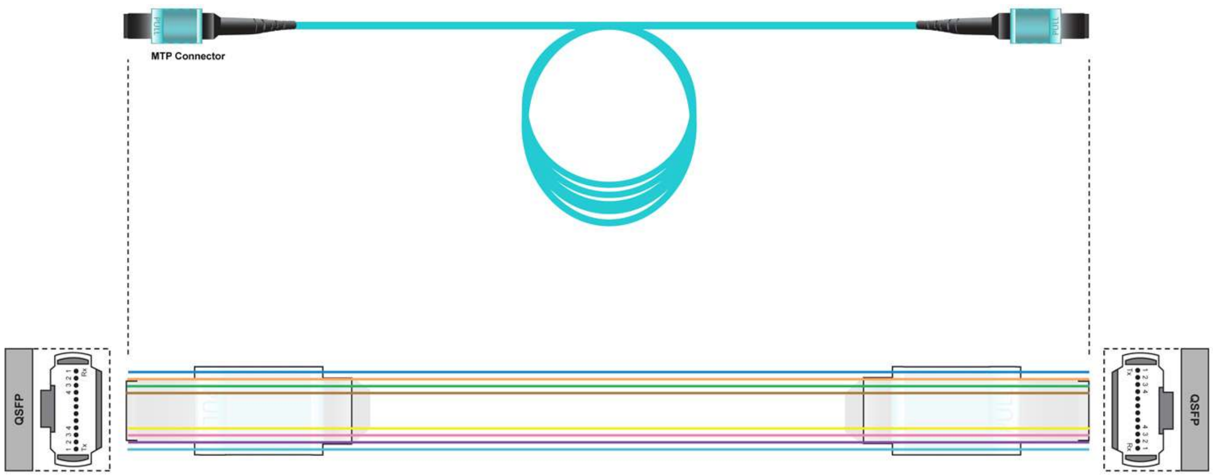


Table 11. Part Numbers

Corning Part Number	Description
J757512TE8-NB010F	12-fiber jumper; MTP (F) to MTP (F); OM3 50/125; overall length of 10 ft
J757512TE8-NB020F	12-fiber jumper; MTP (F) to MTP (F); OM3 50/125; overall length of 20 ft
J757512TE8-NB030F	12-fiber jumper; MTP (F) to MTP (F); OM3 50/125; overall length of 30 ft

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