



Data Center Cabling Guidelines

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1. Introduction

Data center space is growing by millions of square feet every year. They are designed to give customers access to the network infrastructure required for high-speed metropolitan and wide area network connections, data center applications, storage area networks (SANs), Web-hosted Internet applications, Internet service providers (ISPs), e-business applications and many future applications.

Data centers are crucial. They provide the physical environment necessary to house the active and passive networking components that allow reliable network access 24 hours a day, every day of the year. Redundant, multi-path data cabling and redundant power distribution provide a fault-tolerant, reliable operational environment.

Data center facilities must be designed with very specific requirements in mind: HVAC, including temperature-control systems with separate cooling zones; seismically braced racks; smoke detection and fire suppression; secure access; video surveillance, motion sensors and security-breach alarms; and, possibly, other advanced security features. The requirements may require outside specialists in these fields to obtain maximum installation value.

Moreover, space is always a consideration. Economically, more service per square foot is always desirable. High density cabling is the answer, but these infrastructures can become difficult to manage and control. This document provides guidelines for the design and implementation of these critical environments, and discusses design, installation and structured cabling system products that will support the multiple applications found in data centers.

1.1 Scope

The scope of these guidelines is to aid in the design and implementation of a structured cabling system in a data center. These guidelines are not intended to replace or supercede any existing or future cabling standards or any existing related codes or regulations.

1.2 Standards evolution

In TIA, a working group exists under the TIA TR 42.1 sub-committee. This group is called TR-42.1.1, "telecommunications cabling infrastructure for network distribution nodes." They are presently working on a draft standard (SP-3-0092) entitled *Telecommunications Infrastructure Standard for Data Center*, which will be published under the number TIA-942.

This document discusses cabling design, facility design and network design for data centers. Since a data center facility provides high data rate services, TR 42.1.1 will look into high performance copper and optical fiber components specific to data center needs.

The international standards body, ISO, is also presently studying the TIA-942 draft for the creation of a data center standard to add to their documentation. At the time of this printing, ISO had not created a draft document. This is why you will not find any reference to the international standard in this document.

2. Data Centers

Data centers are the new versions of the central offices owned by telephone companies (telco). Whether privately owned or under telco responsibility, the needs of these facilities are the same. High data rate traffic converges in these confined spaces to provide high data capacity and storage services to customers.

Data centers are mission-critical. They must provide uninterrupted and monitored services. Redundancy is an essential element. Power, HVAC and telecommunications redundancy are achieved by using different paths. The operational monitoring center is the central nervous system of the data center. It may be located within the data center facility or at a remote location. No matter where it is, it must remain functional at all times to monitor all links and servers.

Data centers may contain some or all of the following components.

- Internetworking systems
- UPS and diesel backup generators
- Security equipment: access control system, video surveillance, motion detectors, on-premises security officers
- Fire suppression systems, including early detection system
- HVAC climate control, including HVAC sensors
- Operations monitoring system (24-hour)

2.1 Types of data centers

The types of services provided by data centers may vary from privately owned, basic, rented physical space to higher-value-added outsourcing applications such as IT application services.

2.1.1 Private domain

A private domain data center, also known as an enterprise data center, is a facility that is owned by and serves the needs of a private corporation, institution or government agency. It is built, managed and controlled by the owner.

2.1.2 Public domain

- Collocation services: Customers that require extra space for their equipment and/or want security by separating their system from their main networks are looking for collocation services. Data centers will provide a space or cage with proper power and environmental controls where the customer installs its own equipment and is responsible for all the application software used. Usually, the data center will provide a high-speed network connection to allow the customer remote access to its equipment.
- Hosting services: This service can be either shared or dedicated. When shared, the data center will provide the system platform software on which customers run their specific applications software. Customers are then sharing the data center systems. These services include e-commerce and Web hosting. When dedicated, specific applications are supported and maintained on separate systems for a particular customer with access control requirements, no sharing is allowed.

- Managed services: Data centers can monitor and manage dedicated servers provided for customers with higher-level applications software. This provides operational and maintenance functionality for specific network services.

2.2 Data center design – Overview of the project

In the design of a new data center or in the expansion of an existing data center, it is essential to have an overview of the project, including not only the telecommunications cabling needs but also the architectural, electrical and mechanical needs. All specialized sectors must coordinate their work for an efficient turnkey delivery. The designer should consider the following points for the preliminary design of a data center.

- Estimate spaces for full capacity. This applies to telecommunications spaces, pathways, cabling, power and cooling needs.
- Provide architects and engineers with the space requirements (size, pathways entrance, lighting, etc), the flooring/ceiling requirements (floor loading, floor and/or ceiling height, etc), the power and the cooling recommendations.
- Based on the preliminary data center plans, create and establish the location of all required areas, such as the main distribution area, the horizontal distribution area(s), the zone distribution area(s) (if used) and the equipment distribution area(s). Also, plan for the pathway requirements to connect all these areas.
- Design the telecommunications cabling system for today's *and* tomorrow's equipment needs. Consider consolidating standardized and proprietary cabling into a single structured cabling system. This will add versatility, ease of management and facilitate future expansion.

3. Data Center Spaces

As per the draft SP-3-0092 (to be published as TIA-942), new spaces are defined to satisfy the need of data centers.

The new spaces are:

- Computer room
- Entrance room
- Main distribution area (MDA)
- Horizontal distribution area (HDA)
- Zone distribution area (ZDA)
- Equipment distribution area (EDA)
- Data center support area

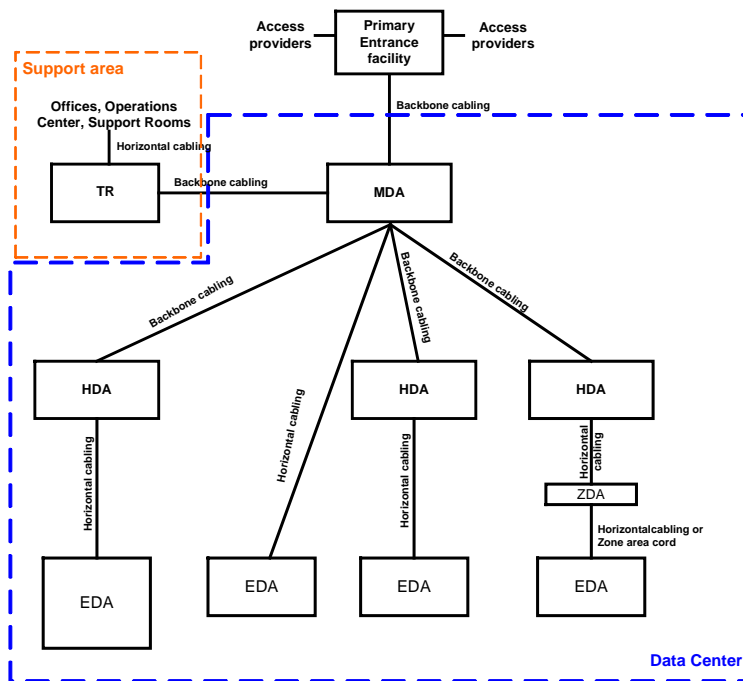


Figure 1: Data center spaces in a star topology configuration

3.1 Computer room

The computer room is a space that supports computer systems, network equipment and related cabling. In the design of the computer room, the following points should be considered.

- Location of the computer room site
 - avoid structural restrictions such as elevators or fixed walls that will limit future expansion
 - provide accessibility for equipment delivery
 - avoid sources of electromagnetic interference
 - avoid exterior windows, for security and environmental reasons
- Requirements for the entrance room
- Requirements for redundancy
- Requirements for air flow
- Requirements for power
- For security and access control, the room shall comply with the requirements of the authority having jurisdiction.
- Location of and requirements for the main distribution area, horizontal distribution area(s), zone distribution area(s) (if used) and equipment distribution area(s)

3.2 Entrance room

The entrance room is a space where the demarcation point is located, i.e. where the ownership changes from the access provider to the customer. This room houses the access provider's equipment, the entrance pathways, the protection for copper cabling (if needed) and the transition point from unlisted cable to listed cable.

Depending on the level of security requested, the entrance room may be located outside the computer room to limit the provider's access to the computer room. Access control should be provided at all time.

For redundancy needs, a secondary entrance room with separate pathways may be required. The design of multiple entrance rooms and the location of each entrance room will be determined by the circuit types and length restrictions. Please refer to the ANSI/TIA/EIA-569-B for additional information on the access provider space requirements and consult the access providers involved for additional information on the circuit types to be installed.

The size of the entrance room should take into consideration the

- entrance pathways for the access providers
- racks or cabinets or cages for the access providers
- demarcation point
- pathways to the computer room
- pathways to the secondary entrance rooms
- customer-owned equipment

3.3 Main distribution area

The main distribution area (MDA) is the space that houses the main cross-connect. It is the central point of the structured cabling system. There should be a minimum of one MDA per data center. To avoid exceeding maximum distance requirements, the MDA should be centrally located. Consideration should be given to having dedicated environmental control and power.

3.4 Horizontal distribution area

The horizontal distribution area (HDA) is the space that houses the horizontal cross-connect. Consideration should be given to having dedicated environmental control and power.

3.5 Zone distribution area

The zone distribution area (ZDA) is the space that houses the zone outlet or a consolidation point. For ease of management, the ZDA should be limited to a maximum of 288 coaxial or twisted-pair connections when the enclosure is either installed overhead or under 2 ft. x 2 ft. (600 mm x 600 mm) access floor tiles. For fiber optic connectivity capacity, it can be treated differently due to the availability of very high-density connectivity modules. Please contact our IBDN Technical Support Team for additional information.

No more than one ZDA shall be placed in a single horizontal cabling link. Cross-connection shall not be used in ZDAs. Termination used in ZDAs may support a consolidation point or a zone outlet.

3.6 Equipment distribution area

The equipment distribution area (EDA) is the space that houses the end equipment, such as the computer systems and telecommunications equipment.

Horizontal cables are terminated in connecting hardware mounted in cabinets or racks. Power and connecting hardware should be provided and installed in a way that minimizes patch cord lengths and power cord lengths, and maximizes ease of administration.

3.7 Data center support areas

Data center support areas are spaces outside the computer room, but they play an important role in the overall function of the data center, such as the operation center, personnel offices, security rooms, electrical rooms, mechanical rooms, storage rooms, etc. These rooms shall be designed and cabled following the commercial cabling standards ANSI/TIA/EIA-569-B and ANSI/TIA/EIA-568-B.1.

4. Redundancy

Time is money, and downtime can bring enormous economic losses to customers. As mentioned, data centers are mission-critical facilities. Redundancy is essential for a secure, reliable data center. To be up and running 7 days a week, 24 hours a day, 365 days a year, design planning becomes very important. Furthermore, beyond a plan for full redundancy, one must include a plan for future expansion. For proper designs for power, environmental controls and internetworking network systems redundancy, we suggest contacting specialists in these fields. Data centers have zero tolerance for downtime; one does not want the power, the environmental controls or the internetworking network system to cause downtime. These redundancy needs must be taken into consideration when planning cabling infrastructure.

4.1 Tiering

Data centers are designed based on the level of availability and security. Four tiering levels apply to data center facility infrastructure, from a basic data center to completely redundant infrastructure. Tiering levels affect the data center facility, its building structure, redundancy levels, telecommunications, and electrical and mechanical systems. For detailed information on tiering, refer to the annex entitled *Data Center Infrastructure Tiers* of the latest draft of SP-3-0092 (to be published as TIA-942) or refer directly to the Uptime Institute Web site at www.uptimeinstitute.com

5. Data Center Pathways

Pathways are the means of physically supporting the telecommunications cabling system. In data centers, the most common pathways used are access floor systems and overhead cable trays.

5.1 Access floor system

As per ANSI/TIA/EIA-569-B standard, the access floor, also known as the raised floor system, is a system consisting of completely removable and interchangeable floor

panels that are supported on adjustable pedestals or stringers (or both). This system allows installation of and access to cable pathways in the area beneath the floor.

Because the cables are hidden under the floor, this system provides a certain level of security and protects the cabling system from accidents/intentional damage that can be caused by easy access.

Access floors shall meet the requirements of ANSI/TIA/EIA-569-B.

Following are specific data center points to consider.

- Consult with your local authority having jurisdiction before deciding on the type of cable to use. In some jurisdictions, plenum cable is the minimum requirement for telecommunications cabling under data center access floors.
- Cables shall not be left abandoned in pathways under the access floor. Cables shall have at least one end terminated. Otherwise, non-identified cables shall be removed.
- Cable trays shall be bonded and grounded as per the authority having jurisdiction.
- The design of the cable tray should be coordinated with architects and mechanical and electrical engineers to make sure that cable trays, lightning, plumbing, air ducts, power and fire protection systems do not interfere with each other.

5.2 Overhead cable tray system

Overhead cable tray systems consist of cable trays installed in the space between the racks/cabinet and the ceiling. One of the advantages of this system is the possibility of having multiple layers of cable trays, with each layer supporting a specific cable type. For example, one layer can be for power cabling, one for copper cabling and another for optical fiber cabling. Layering the cable trays greatly facilitates separation of power and telecommunications cables.

Overhead cable tray access shall meet the requirements of ANSI/TIA/EIA-569-B.

Following are specific data center points to consider.

- Overhead cable trays should be suspended from the ceiling.
- For security reasons, cable trays should have solid bottoms or be placed at least 2.7 m (9 ft.) above the finished floor to limit accessibility.
- Cables shall not be left abandoned in overhead cable trays. Cables shall have at least one end terminated. Otherwise, non-identified cables shall be removed.
- Cable trays shall be bonded and grounded as per the authority having jurisdiction.
- The design of the cable tray should be coordinated with architects and mechanical and electrical engineers to make sure that cable trays, lightning, plumbing, air ducts, power and fire protection systems do not interfere with each other.

5.3 Separation of power and telecommunications cables

Specific separations are recommended between power cables and twisted-pair cables. These separations reduce the noise coupling effect from the power cables to the telecommunications cables. The separation guidelines provided accommodate data

center environments, which are different than typical office environments or telecommunications room.

The following table provides distances that shall be maintained between electrical power cables and twisted-pair cables in a data center environment. It is possible that electrical codes require a barrier or a separation greater than specified (e.g. 50 mm / 2 in.) in the following table. Refer to NFPA 70, article 800 or the applicable electrical code for additional information.

Table 1: Separation guidelines between twisted-pair and shielded power cables

| Number of circuits | Electrical circuit type | Separation distance (mm) | Separation distance (in.) |
|--------------------|---------------------------------------------|--------------------------|---------------------------|
| 1 –15 | 20A 110/240V 1-phase shielded or unshielded | Refer to 569B annex C | Refer to 569B annex C |
| 16 – 30 | 20A 110/240V 1-phase shielded | 50 mm | 2 in. |
| 31 – 60 | 20A 110/240V 1-phase shielded | 100 mm | 4 in. |
| 61-90 | 20A 110/240V 1-phase shielded | 150 mm | 6 in. |
| 91+ | 20A 110/240V 1-phase shielded | 300 mm | 12 in. |
| 1+ | 100A 415V 3-phase shielded feeder | 300 mm | 12 in. |

5.4 Racks and cabinets

When racks or cabinets are used, they should be installed so that all cabinet/rack fronts face each other, creating “cold” aisles. The backs of the cabinets/racks create the “hot” aisles.

- Telecommunications cables should be installed in cable trays installed under the access floor of the “hot” aisles.
- Power cables should be installed in cables trays installed under the access floor of the “cold” aisles.
- Active equipment should be installed in cabinets/racks with the cold air intake from the front and hot air exhaust out the back.
- When cabinets/racks are installed on the access floor, they should be installed so that floor tiles in “hot” and “cold” aisles can be lifted to gain access to the underfloor area.

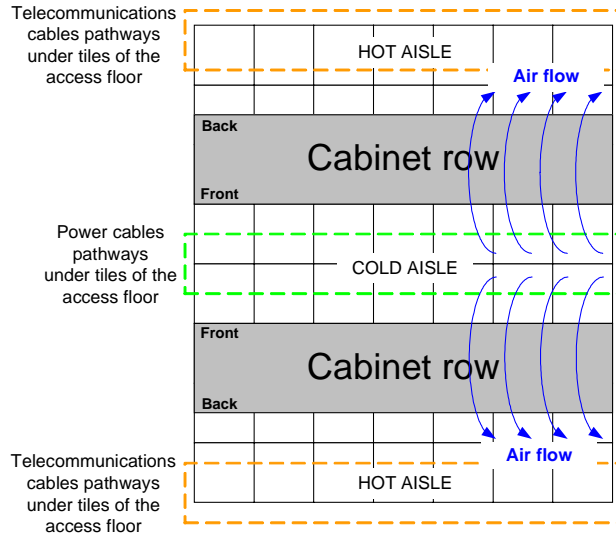


Figure 2: Example of cabinet configuration

6. Cabling Considerations

6.1 Topology

The topology recommended for data centers is the star topology (see Figure 1). A star topology is a cabling configuration in which the nodes are individually connected to one common point, or hub. This facilitates moves, adds and changes (MACs) with virtually no network downtime and with easier administration.

6.2 Recognized media

- 100-ohm twisted-pair cable, ANSI/TIA/EIA-568-B.2 (Category 6 is recommended, ANSI/TIA/EIA-568-B.2-1), with associated connecting hardware, jumpers, patch cords, equipment cords and zone area cords
- multimode optical fiber cable, ANSI/TIA/EIA-568-B.3 (850 nm laser-optimized 50/125 μm multimode fiber is recommended, ANSI/TIA-568-B.3-1), with associated connecting hardware, jumpers, patch cords, equipment cords and zone area cords
- singlemode optical fiber cable (ANSI/TIA/EIA-568-B.3) with associated connecting hardware, jumpers, patch cords, equipment cords and zone area cords
- 75-ohm (734 and 735 type) coaxial cable with associated connecting hardware, jumpers, patch cords, equipment cords and zone area cords is recognized to support specific applications (refer the clause 6.6 for additional information)

6.3 Horizontal cabling

Horizontal cabling links the EDA to the HDA. The maximum horizontal cable length between the EDA and the HDA shall not exceed 90 m (295 ft.), independent of media type. Depending on the application, some media may be able to exceed this distance. Refer the clause 6.6 for additional information.

A ZDA allows easy reconfiguration. No more than one ZDA shall be placed in a single horizontal cabling link. Termination used in a ZDA may be a consolidation point or a zone outlet. Refer to clause 3.5 for additional information on ZDAs.

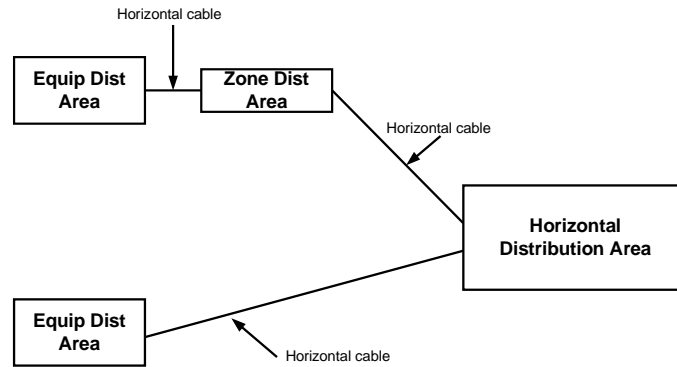


Figure 3: Horizontal cabling topology

6.3.1 ZDA with a consolidation point

The consolidation point is an interconnection point within the horizontal cabling. The consolidation point performs a “straight-through” intermediate interconnection between the horizontal cable coming from the horizontal cross-connect and the horizontal cable going to the termination at the EDA. Cross-connections between these cables at the consolidation point are not allowed. A consolidation point may be useful when reconfiguration is frequent, but not so frequent as to require the flexibility of a zone outlet.

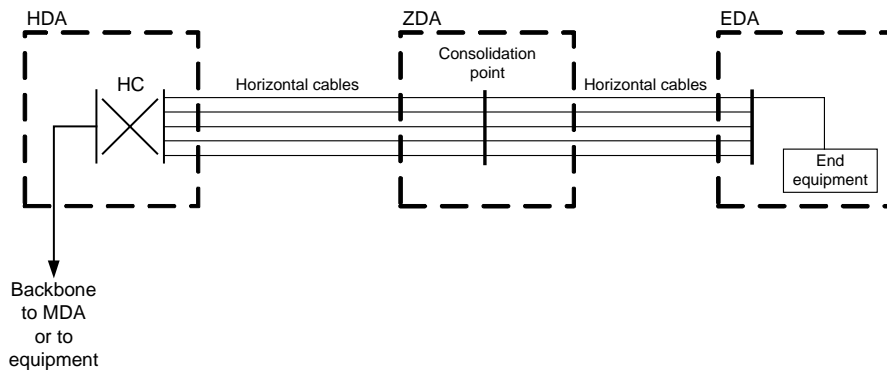


Figure 4: ZDA configuration with a consolidation point

6.3.2 ZDA with a zone outlet

From an architectural perspective, the zone outlet is to data center cabling what the MUTOA is to commercial building cabling.

The zone outlet is a termination point for the horizontal cabling, consisting of several telecommunications outlets in a common location. The zone area cord extends from the

zone outlet to the terminal equipment without any additional intermediate connections. This configuration allows MACs without affecting the horizontal cabling.

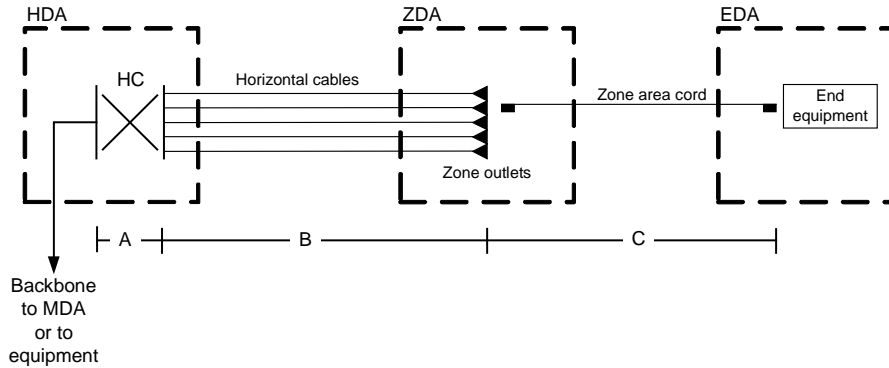


Figure 5: ZDA configuration with zone outlets

Table 2: Channel length in a ZDA configuration with zone outlets

| A meters (feet) | B meters (feet) | C meters (feet) | Total channel length meters (feet) |
|--------------------|--------------------|--------------------|---------------------------------------|
| 5 (16) | 90 (295) | 5 (16) | 100 (328) |
| 5 (16) | 85 (279) | 9 (30) | 99 (325) |
| 5 (16) | 80 (262) | 13 (44) | 98 (322) |
| 5 (16) | 75 (246) | 17 (57) | 97 (319) |
| 5 (16) | 70 (230) | 22 (72) | 97 (319) |

Note: There is no channel length penalty when using solid modular cords in a ZDA: the total channel length may remain at 100 m (328 ft.).

6.4 Backbone cabling

In the data center cabling structure, backbone cabling provides interconnections between HDAs, MDAs and entrance facilities. Backbone cabling consists of inter-building cables, backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.

Backbone media selection for data applications is dependent upon the distance between termination points and the data rate of the application to be installed. Refer to clause 6.6 for more information.

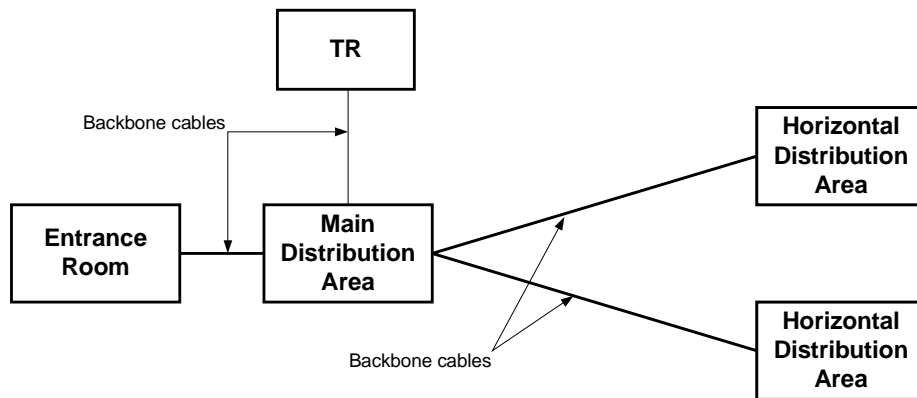


Figure 6: Backbone cabling topology

6.5 Centralized optical fiber cabling

Centralized optical fiber cabling allows data centers to consolidate most active equipment in the MDA, greatly increasing security and easing system administration. The EDA can then be linked directly to the MDA via an optical fiber.

Points to consider:

- The EDA connections are extended to the main cross-connect in the MDA by utilizing either pull-through cables, an interconnect or a splice in the HDA.
- Use of an interconnection between the horizontal and backbone cabling provides the greatest flexibility, ease of manageability and can easily migrate to a cross-connect or interconnect system.
- The distance of horizontal and backbone cabling combined with an EDA and cross-connect patch cord is not to exceed 300 m (984 ft.). By adhering to 300 m (984 ft.), a multimode optical fiber cabling system will support future multi-gigabit applications (since cable length is dependent on the fiber type and the application, refer to the 6.6 for additional information).
- Centralized cabling systems shall be located in the same building as the EDA(s) being served. All move and change activity shall be performed at the main cross-connect. Horizontal links should be added and removed in the HDA when the interconnect or splice design is used.
- Slack can be stored as either cable or unjacketed fibers. When storing slack, provisions shall be made to ensure bend radius limitations are not violated. A length of 3 to 6 m of cable slack is recommended to allow enough cable for repair and/or relocation. Cable slack can be stored within an enclosure or on the wall of the telecommunications room. Preferably, unjacketed fiber slack should be stored within an enclosure. Remember that the cable slack has to be included in the 300 m maximum cable length allowed.

6.6 Applications versus distances

The media selection for data applications is dependent upon the distance between termination points and the data rate of the application to be installed, the data network speed, the applications used and the type of media required. Optical fiber cable is recommended where the channel length exceeds 100 m (328 ft.) or when the application requires it. Refer to the annex entitled *Cabling Design Consideration* of the latest draft of SP-3-0092 (to be published as TIA-942) for additional information.

Table 3: Maximum channel lengths in relation to specific applications

| Applications | Maximum supported channel distance (informational only) | | | | | | | | |
|------------------------------------------------------|---------------------------------------------------------|---------------|-----------------------|----------------------------|------------------|---------------------------|------------------|----------------------------------------|--------------------------|
| | 734 type coax | 735 type coax | Category 3 unshielded | Category 5e & 6 unshielded | Wave length (nm) | From ANSI/TIA/EIA 568-B.1 | | | |
| | | | | | | Multi-mode 62.5µm | Multi-mode 50µm | Multi-mode 850 nm laser-opt. 50/125 µm | Single-mode ⁸ |
| EIA/TIA -232-F EIA/TIA-561 For up to 20 kb/s | | | 23.2 | 27.4 | | | | | |
| EIA/TIA -232-F EIA/TIA-561 For up to 64 kb/s | | | 8.1 | 9.5 | | | | | |
| T1 ¹¹ | | | 146 | 198 | | | | | |
| T3 ¹¹ | 263 | 117 | 102 | 146 | | | | | |
| E1 ¹¹ | 132 | 67 | | | | | | | |
| E3 ¹¹ | 143 | 73 | | | | | | | |
| 10BASE-T | | | 100 | 100 | | | | | |
| 10BASE-FL (Ethernet) | | | | | 850 | 2000 | 2000 | 2000 | - |
| Token Ring (4/16 Mb/s) | | | | 100 | 850 | 2000 | 2000 | 2000 | - |
| 100BASE-T | | | | 100 | | | | | |
| Demand Priority ¹ (100 VG-AnyLAN) | | | | | 1300 850 | 2000 500 | 2000 500 | 2000 500 | - - |
| 100BASE-FX (Fast Ethernet) | | | | | 1300 | 2000 | 2000 | 2000 | - |
| FDDI (low cost) | | | | | 1300 | 500 | 500 | 500 | - |
| FDDI (Original) | | | | | 1300 | 2000 | 2000 | 2000 | 40 000 |
| ATM | | | | | | | | | |
| 52 Mb/s | | | | | 1300 | 3000 | 3000 | 3000 | 15 000 |
| 155 Mb/s | | | | | 1300 | 2000 | 2000 | 2000 | 15 000 |
| 155 ⁷ Mb/s | | | | | 850 | 1000 | 1000 | 1000 | - |
| 622 Mb/s | | | | | 1300 | 500 | 500 | 500 | 15 000 |
| 622 ⁷ Mb/s | | | | | 850 | 300 | 300 | 300 | - |
| Fiber Channel | | | | | | | | | |
| 133 MB | | | | | 1300 | 1500 | 1500 | 1500 | - |
| 266 MB | | | | | 1300 | 1500 | 1500 | 1500 | 10 000 |
| 266 ⁷ MB | | | | | 850 | 700 | 2000 | 2000 | - |
| 531 ⁷ MB | | | | | 850 | 350 | 1000 | 1000 | - |
| 531 MB | | | | | 1300 | - | - | - | 10 000 |
| 1062 ⁷ MB | | | | | 850 | 300 ² | 500 | 500 | - |
| 1062 MB | | | | | 1300 | - | - | - | 10 000 |
| 2125 ⁷ MB | | | | | 850 | 150 | 300 | 300 | - |
| 2125 MB | | | | | 1300 | - | - | - | 10 000 |
| 4250 ⁷ MB | | | | | 850 | 70 | 150 | 150 | - |
| 4250 MB | | | | | 1300 | - | - | - | 10 000 |
| 1000BASE-TX | | | | 100 | | | | | |
| 1000BASE-SX ⁷ (1 Gigabit Ethernet) | | | | | 850 | 220 ³ | 550 ⁴ | 550 | - |
| 1000BASE-LX ⁷ (1 Gigabit Ethernet) | | | | | 1300 | 550 ¹⁰ | 550 | 550 | 5 000 |
| 10GBASE-S ⁷ (10 Gigabit Ethernet) | | | | | 850 | 33 ^{5,10} | 82 ⁶ | 300 | - |
| 10GBASE-L ⁷ (10 Gigabit Ethernet) | | | | | 1300 | - | - | - | 10 000 |
| 10GBASE-E ⁷ (10 Gigabit Ethernet) | | | | | 1550 | - | - | - | 30 000 |
| 10GBASE-LX4 ^{7,10} (10 Gigabit Ethernet) | | | | | 1300 | 300 | 300 ⁹ | 300 | - |

1. Application specifies 62.5 μm fiber with 200 MHz-km bandwidth at 850 nm.
2. 300 m capability specified in fiber channel update, FC-PH-2.
3. For 62.5 μm fiber, IEEE specifies 220 meters for 160/500 MHz-km modal bandwidth and 275 meters for fiber with 200/500 MHz-km modal bandwidth.
4. For 50 μm fiber, IEEE specifies 500 meters for 400/400 MHz-km modal bandwidth and 550 for 500/500 MHz-km modal bandwidth.
5. For 62.5 μm fiber, IEEE specifies 26 meters for 160/500 MHz-km modal bandwidth and 33 meters for fiber with 200/500 MHz-km modal bandwidth.
6. IEEE 10GBASE-S specifies for 50 μm fiber 66 meters for 400/400 MHz-km modal bandwidth and 82 meters for 500/500 MHz-km modal bandwidth.
7. This is a laser-based application. When not so noted, multimode applications are LED-based.
8. Power budget and distance capability depends on classification option of transmitter and receiver. Distance specified is for the highest power budget option.
9. IEEE 10GBASE-LX4 specifies for 50 μm fiber 240 meters for 400/400 MHz-km modal bandwidth and 300 meters for 500/500 MHz-km modal bandwidth.
10. Mode launch conditioning patch cord may be required to obtain the maximum distance when using 62.5 μm fiber. A mode launch conditioning patch cord is a cord that focuses light in a specific area in the core of the fiber. This cord allows the distribution of the light in a multimode fashion to achieve optimum distances. For 1GBASE-LX application and 10GBASE-S, this cord may or may not be needed depending on the type of multimode fiber cable used; with NORDX/CDT's FX300, the mode launch conditioning patch cord is not necessary. For 10GBASE-LX, IEEE recommends the use of a mode launch conditioning patch cord for all multimode fibers; with NORDX/CDT's FX fibers, the mode launch conditioning patch cord is not necessary.
11. Maximum circuit distances for a typical data center configuration. The values provided are still subject to change; please refer to the latest TIA draft SP-3-0092 for additional information.

7. Cabling Design Challenges

Following are some challenges that cabling designers may have to deal with.

7.1 High data rate and high bandwidth cabling infrastructure requirements

The need for high data rates and high bandwidth is increasing. The publication of the standard from IEEE on 10-gigabit Ethernet over optical fiber certainly is of interest to data center and SAN applications. Both singlemode and multimode optical fiber systems are found in a data center.

Where a singlemode optical fiber system is used, the capacity for 10 Gb/s becomes less limited, compared to multimode. Singlemode optical fibers, often used in long-haul applications, are usually found outside the facility up to the demarcation point. Data center managers will decide if they want to continue inside their facilities with singlemode or multimode fiber. Active equipment is the driving force for using one type of fiber over the other. Singlemode optical equipment uses laser technology, which is more expensive.

Where multimode is considered, we suggest using the 850 nm laser-optimized 50/125 μm multimode optical fiber. This fiber will support up to 10 Gb/s applications over 300 m of cable (refer to *10 Gb/s: Information for LAN Design Considerations*, a white paper available at www.nordx.com). As specified by the IEEE and TIA standards organizations, multimode optical fiber becomes limited when data rates reach 10 Gb/s, in both channel attenuation budget and channel length. In a data center or SAN environment, multimode optical fiber can be an interesting solution due to lower cost of the active equipment and the shorter connection distances usually encountered in these environments.

Where copper is used, unshielded twisted-pair cable is first in line. Although both Category 5e and 6 systems can support data rates in the gigabit range, Category 6 is the recommended media due to its high performance and additional available margin.

Even if it is limited to a maximum length of 100 m, copper is an economical solution for connecting equipment within the same facility. Specific design recommendations must be adhered to when copper cabling is installed in environments with high electromagnetic interference (EMI); refer to clause 5.3 for additional information on power separation.

7.2 Flexibility and connectivity

The *time is money* axiom also applies to cabling infrastructure. A cabling system that allows for flexibility and easy reconfiguration minimizes downtime and maximizes profit. Flexibility depends on the device media interface and the product line used and, here, connectivity is an important consideration. Maximizing profit requires that the maximum pair-count be installed in the smallest possible space.

For optical fiber connectivity, the small form factor (SFF) connector is one solution offered on the market for high-pair-count optical fiber connectivity. The most popular is the LC type connector. This connector is a single connector that when paired to provide two fibers (the transmit signal on one fiber and the received signal on the other fiber) fits in a small footprint the size of a RJ-45 type copper connector. The LC type of SFF connector allows high-density installations.

The MPO connector is also a connector type that can be used use in data center facilities. It allows up to 12 fibers to be terminated in a single connector. This connector offers high density and high flexibility as well as ease of installation and reconfiguration.



Figure 7: NORDX/CDT's MPO connector

For copper connectivity, the traditional RJ-45 connector is well known in the telecommunications industry and is still widely used in data center installations. Also, an insulated displacement connector such as that used in the GigaBIX system offers a high-pair-count installation using the cross-connect wire system. Both systems are very flexible and permit easily expandable installations.



Figure 8: NORDX/CDT's GigaFlex PS6+ module and GigaBIX connector

7.3 Optical fiber budget allocation

When designing a fiber cabling system, it is important to ensure not only that the fiber link does not exceed the maximum length, but also that the total end-to-end attenuation of the fiber link is well within the operating parameters of the optical electronics to be used. If the end-to-end attenuation exceeds the difference between the strength of the transmitter and the sensitivity of the receiver, the signal may not reach the far end of the fiber link.

When optical fiber link segments are cross-connected to form an end-to-end path between two locations, the sum of the attenuation of each link segment shall always be less than the link loss budget. This means the number of connections per link and the attenuation of the optical fiber cable are very important.

Because cable attenuation is controlled by the manufacturer, the cabling designer and cabling installer's major concern will be the performance of the connector chosen. NORDX/CDT's OPTIMAX is a revolutionary field-installable optical fiber connector. The unique design of the patented mechanical splice body of Optimax incorporates a factory-mounted fiber stub and a pre-polished ceramic ferrule that consistently provides a fast, secure and reliable multimode or singlemode optical fiber cable termination. All critical steps are performed in the factory, ensuring a superior quality connection every time.

Please refer to the IBDN Optical Fiber Design Guide for additional information on budget calculation and budget allocation per application.

7.4 Cabling management

High-pair-count connector installation introduces cable slack and patch cord management issues. As in all types of installations, proper training and limited access are important cabling management control concerns. It is best to strictly limit access to certified installers and trained persons responsible for MACs. These individuals must possess the skills needed to follow the rules provided by the cabling manager.

Specialized products for the management of slack and patch cords — horizontal and vertical channel managers, rings, hooks and panels — are important facility design considerations. Proper planning will allow for expansion, avoiding future capacity problems. Furthermore, due to the critical nature of many applications, seismic phenomenon also must be considered. Racks and cabinets must meet seismic requirements.

7.5 Administration of the cabling infrastructure.

The ANSI/TIA/EIA-606-A standard, *Administration Standards for the Telecommunications Infrastructure of Commercial Buildings*, provides requirements to manage the structured cabling system. This TIA document along with the annex entitled *Telecommunications Infrastructure Administration* of the draft SP-3-0092 (to be published as TIA-942) will provide proper guidance for a data center installation.

Keep in mind, controlled access and proper training are essential to cabling system administration. It may take time to get all the needed information registered properly at first, but in the long run it will save significant time if an emergency arises.

8. NORDX/CDT Optical Fiber Structured Cabling Solutions

NORDX/CDT offers the *FiberExpress* solution. It is more than a simple assemblage of products. It is a new approach to the methodology of fiber optic cabling that eliminates the problems usually associated with optical fiber networking.

Beyond the well known traditional benefits of optical fiber systems, *FiberExpress* solutions offer:

- High density installation
- Reduced conceptual complexities
- Greater deployment facility
- Quick installation
- Increased flexibility
- Easier moves, adds and changes (MACs)
- Cost effectiveness

8.1 *FiberExpress* Manager

The cornerstone of the system is the *FiberExpress* Manager, a modular assembly approach that facilitates simple, flexible, high-density installations and the management of large numbers of high-density terminations. The *FiberExpress* Manager shelf solution (NORDX/CDT's highest density solution) allows up to 1,920 singlemode and multimode fiber terminations in a single rack (when using multiple shelves). It adapts to most connectors, including SC, SC duplex, ST compatible, LC, MT-RJ or MPO. It also offers conventional or pre-terminated solutions for easier installation.

The basic building block of the *FiberExpress* Manager is the connector module designed with a unique release mechanism that allows it to slide out one inch on the front side, easing management of patch cords. Full maintenance is achieved by pulling the modules out at the back. Vertical and horizontal cable management panels provide extensive support and bend radius protection for fiber deployment. The module has angle-mounted connectors for easy access and bend radius requirements.

The *FiberExpress* Manager is part of a system that can be easily implemented in a data center or SAN environment. The management characteristics of this system are perfect for high-fiber-count installations. The management accessories and modularity of the products will facilitate MACs. Moreover, the pre-terminated solutions provide reliable, quick and easy installation and reconfiguration.



Figure 9: FiberExpress Manager system

The addition of the 1U Rack Mount Patch Panel to the FiberExpress family perfectly complements the solution. It is a compact assembly designed for interconnection or splicing of optical fiber cables, from 6 to 36 fibers, using up to three FiberExpress Manager modules. The low-profile design minimizes rack space to only 1U (45 mm, or 1.75 in.). It can be used with ST Compatible, SC, 568SC, FC, LC or MT-RJ FiberExpress Manager modules (regular or pre-terminated versions) with any connector count (6-, 8- or 12- fiber).

In a data center configuration, the FiberExpress Manager 1U Rack Mount Patch Panel can be used for fiber termination in the HDA to the FiberExpress Manager shelf system, typically located in the MDA. The FiberExpress Manager 1U Rack provides the system with high connection density while facilitating cable routing and patch cord management.

8.2 Fiber patch cords

Color-coding patch cords is a good way to ease administration. Fiber patch cords should not be an exception to this rule. NORDX/CDT has the ability to customize fiber patch cords with various cable jacket colors and various high-quality fiber connectors (e.g. multimode SC Duplex to LC Duplex with red jacket).

8.3 Field-installable optical fiber connectivity

NORDX/CDT's Optimax is a revolutionary field-installable optical fiber connector. The connector does not require any epoxy and comes factory polished, providing a connector that is easy to install, safe to use and provides consistency in the loss termination results. Its pre-radiused PC ceramic ferrule ensures contact between optical fibers, improves durability and provides high performance. Also, since the Optimax connector is easy to install, it is ideal for mission-critical environments where quick repairs are essential.

This connector is offered for both multimode and singlemode LC, SC and ST compatible connectors, allowing NORDX/CDT to provide a complete fiber termination solution. The connector comes with an easy installation manual and Optimax training video on CD for efficient and consistent training of field service personnel.

8.4 Small form factor (SFF) fiber connectors

The small form factor (SFF) connector is a physically compact connector solution for high-fiber-count optical fiber systems. Although there are many different types of SFF connectors on the market, the most popular is the LC type connector. The LC technology represents the highest performing high-density option available, by far.

The NORDX/CDT Optimax LC connector is unique in that it is the only no-epoxy/no-polish field-installable connector to feature a spring-loaded ferrule, allowing the connector to be mated with any LC connector on the market. The patented Optimax LC connector also features a pre-radiused PC ceramic ferrule which ensures contact with optical fibers, improves durability, and provides high performance connections. Since the Optimax LC connector is part of NORDX/CDT's Optimax family, this connector offers all the same advantages as the connectors in that family and more.

8.5 Additional security through fiber connectivity

Fiber is the media of choice for high-security applications. Data center installations often use various fiber connectors to segregate and control access to various security levels running on parallel networks. Another way to achieve the same objective would be to use one style of connector with a built-in keying system to prevent connection errors. This system has the advantage of using one style of connector, all delivering the same performance and all requiring the same installation procedure. It is important that the solution chosen be able to support applications with data rates up to 10Gb/s, using either a multimode fiber optic system or a singlemode fiber optic system.

NORDX/CDT's *FiberExpress* Secure/Keyed LC system allows for physical segregation of network segments in secure fiber cabling infrastructures. These products have been designed for the specific uses of government and military installations, but with security also being a major concern for business, the use of these products can be advantageous in many of today's installations, such as data centers.

The product line includes IBDN *FiberExpress* Manager connector modules, patch cords, adapter strips and adapter modules. These products are available with six different keying options, each carrying a different color to facilitate network administration. The

patent-pending keying detail inside the components is totally tamper-proof and cannot be reproduced inside a standard LC adapter. Furthermore, all modules used in this product line are keyed both on the front and on the back to prevent installation errors and security breaches.

9. NORDX/CDT Copper Structured Cabling Solutions

9.1 GigaBIX cross-connect system

The GigaBIX cross-connect system is a wall mount or rack mount system that provides a usable bandwidth of up to 300 MHz and a data rate of up to 4.8 Gb/s when installed in an IBDN 4800LX System using either the GigaBIX cross-connect wire or the GigaBIX patch cords. For data center and SAN applications, we propose the GigaBIX cross-connect system using the GigaBIX cross-connect wire.

The GigaBIX connector is the core component of the GigaBIX cross-connect system. Its symmetrical construction allows termination of high-performance cables on one side and GigaBIX cross-connect wire on the other. The GigaBIX connector offers exceptional performance that goes beyond Category 6, which makes it the ideal choice for gigabit cabling networks.

GigaBIX cross-connect wire guarantees **Beyond Cat 6™** performance when installed in an IBDN System 4800LX, allowing very flexible cost-effective installations. It offers the best price-to-performance ratio since the GigaBIX cross-connect wire system provides the highest installation density possible — up to one pair per square inch for a complete system, including wire management — which reduces installation space requirements. Furthermore, in this system, each wire is cut to length, a feature that eliminates slack management, guaranteeing installation aesthetics and easy management, even after numerous moves, adds and changes.

In a data center or SAN environment, system security is very important. One of the many benefits of the GigaBIX cross-connect system is that all MACs must be done by certified installers, limiting the number of people who can work on the cabling system and thus providing additional system security.

Redundancy is an integral characteristic of a data center and SAN, but redundancy carries a very high cost. The GigaBIX cross-connect system, with its best price-to-performance ratio, can provide both redundancy and a very high pair-count copper installation at a very attractive price.

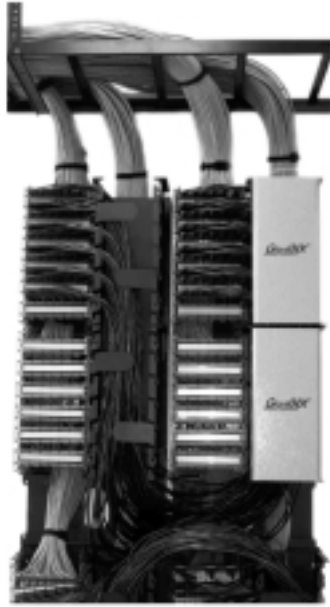


Figure 10: GigaBIX system

9.2 Rack-mount modular patch panel system

Rack-mountable patch panels are designed to fit in standard 19-inch or 23-inch racks or cabinets. All patch panels use 8-position (RJ-45) modular patch cords for the cross-connect cable and/or equipment cable.

PS6+ Flex patch panels use snap-in *GigaFlex* PS6+ modules. The unmatched PS6-rated performance of this module exceeds all parameters specified in the Category 6 standard and guarantees transmission performance up to 300 MHz when used in a IBDN 4800LX system.

Again, management accessories are part of the product line: vertical and horizontal management panels, organizer panels and trays, cable support brackets (front and back), and more.

The maximum capacity of a standard 7-ft. rack varies considerably depending on the organizer panels used and the hub location. A standard 7-ft. rack can accommodate up to 44 U (rack unit U = 1.75 in. or 45 mm).

The cross-connections between the distribution and equipment fields are made using modular patch cords, which allow easy MACs.

NORDX/CDT PS6+ Flex patch panels and *GigaFlex* PS6+ modules offer modularity and easy management, valuable features in patch panel type installations for a data center or SAN environment. Moreover, *GigaFlex* PS6+ connectivity provides **Beyond Cat 6™** performance.



Figure 11: PS6+ Flex patch panel kit (1U - 24 ports)

NORDX/CDT's investment in research and development programs allows it to consistently produce innovative products and systems. NORDX/CDT conceives, designs, produces and markets a range of cabling, connectivity and end-to-end system products. Because the NORDX/CDT product line offers modularity and myriad accessories, it allows end users to customize their cabling solutions, incorporating the amount of flexibility desired. NORDX/CDT can say its products allow solutions tailored to each customer's needs.

9.3 Structured cabling monitoring systems

Unlike everything else in the IT network, structured cabling is essentially invisible to the IT team, which makes the cabling difficult to accurately monitor and manage. It is simply impossible to see all of this critical layer that connects passive components and supports the entire network infrastructure. Intelligent Physical Layer Management Solutions (IPLMS) eliminates this black hole by allowing real-time monitoring of structured cabling via sensors embedded in the structured cabling system. These sensors forward system information to a centralized database in real-time. The database then analyzes the information and, when a change is recorded, takes the appropriate, user-defined action.

Such features allow rapid detection of and response to changes, which is critical to any network, including the ones found in data centers. In an intelligent network environment, the system automatically detects items connected to the physical network and correlates them with a log of connectivity changes and a record of device locations. By pre-defining the escalation process, network administrators can determine both when to receive instant notification about network issues and what the notification process will be. Unauthorized or unscheduled changes can trigger alarms or alerts, such as phone calls, e-mail messages or pages containing a predefined message.

The IntelliMAC-Plus solution can be implemented in systems that include multiple buildings located in different cities. All the system information is gathered on one server, allowing surveillance of all IT rooms from a central security location.

These features dramatically increase security by helping the security manager to

- Localize rogue events — accurate, real-time mapping of network topology, lets IntelliMAC-Plus “see” an event such as an unauthorized computer connection, log it, pinpoint its physical location (room number, for example) and alert IT personnel with fully customizable alarms (paggers, e-mails, etc.).

- Control access — the system enables monitoring and activation of various access control devices: cabinet room doors can be opened or locked by the system, opening cabinet doors can trigger alarms, etc.
- Monitor link security — the user can define an escalation procedure to alert personnel when a non-planned MAC is detected or an important network component is physically disconnected. An escalation of alerts can include an audible alarm, e-mail notification, a page, or a combination of alerts to the IT manager and/or other designated personnel.

IntelliMAC-Plus facilitates remote management of all issues related to the structured cabling system — 24/7 — even from an offsite management location.

10. Certified Cabling System

NORDX/CDT offers the industry's most comprehensive warranty program, including a 25-year product warranty and a lifetime Application Assurance Program. IBDN certification is the key to ensuring that the IBDN system is designed and installed as per NORDX/CDT's requirements, thus allowing the end-user to obtain optimal performance. Certification provides the guarantee needed to protect the data center networking investment now and in the future.

For additional information on NORDX/CDT's product line or certification program, please visit our Web site at www.nordx.com or consult our IBDN catalog and reference guide.

To find a NORDX/CDT Customer Service Vendor (CSV), distributor or consultant near you, please visit the **Partner's** section on our Web site at www.nordx.com.

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