Application Notes

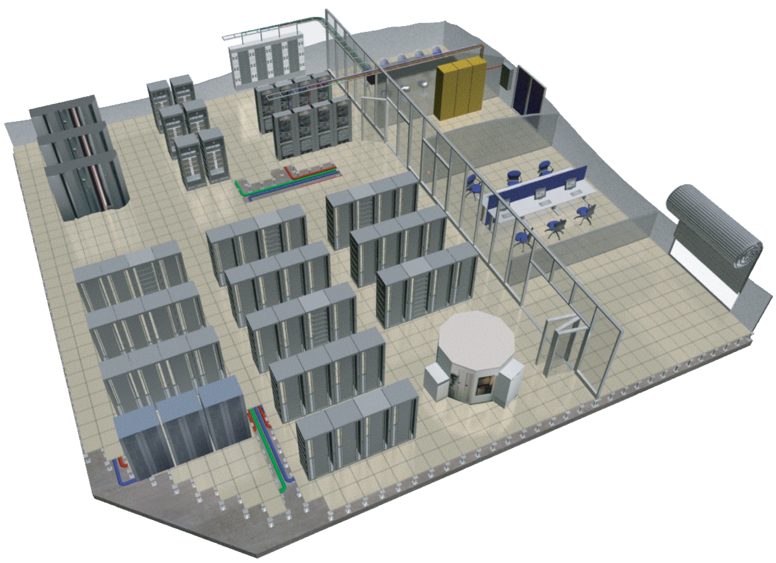
April 2007

Data Center Infrastructures - High in Fiber, Low in Network Saturates

Data Centers (DCs) offer high performance server hosting, data storage and redundant business backup, devoted to providing a secure and reliable environment for large numbers of application servers, switches and storage devices. Providing these servers with redundant high-speed access to the Internet and corporate intranet is also a primary feature of these centers. DCs use high-speed equipment and support high equipment densities, so environmental systems (especially cooling) are also very important.

With **extreme service reliability** being a trademark of these installations, DCs are addressed with high quality cabling solutions that allow for:

- Operational reliability
- Quick changes, including additions and rapid expansion
- Enhanced management, monitoring and service provisioning
- High density
- High bandwidth
- Flexibility and modularity
- Secure access



Data Center Equipment Layout

SYSTIMAX® SOLUTIONS

Standards

Data center networking has moved past the stage of simply connecting servers and switches together. As companies broaden their definition of the data center from “computer room” to “strategic corporate asset,” the importance of data center optimization rises. If strong new data centers are a measure of corporate health, a reliable, flexible and resilient network infrastructure is a must. The physical layer infrastructure needs to be robust and versatile enough to support 24/7 availability and monitoring, “5 nines” reliability, redundancy, security, fire prevention, environmental control, rapid deployment/ rearrangements and business continuity management.

The good news for data center management is that global infrastructure standards organizations have recognized the daunting tasks IT personnel face and guidelines are being formulated with recommendations for preferred high performance cabling infrastructures. In the U.S., an infrastructure standard for data centers is covered by:

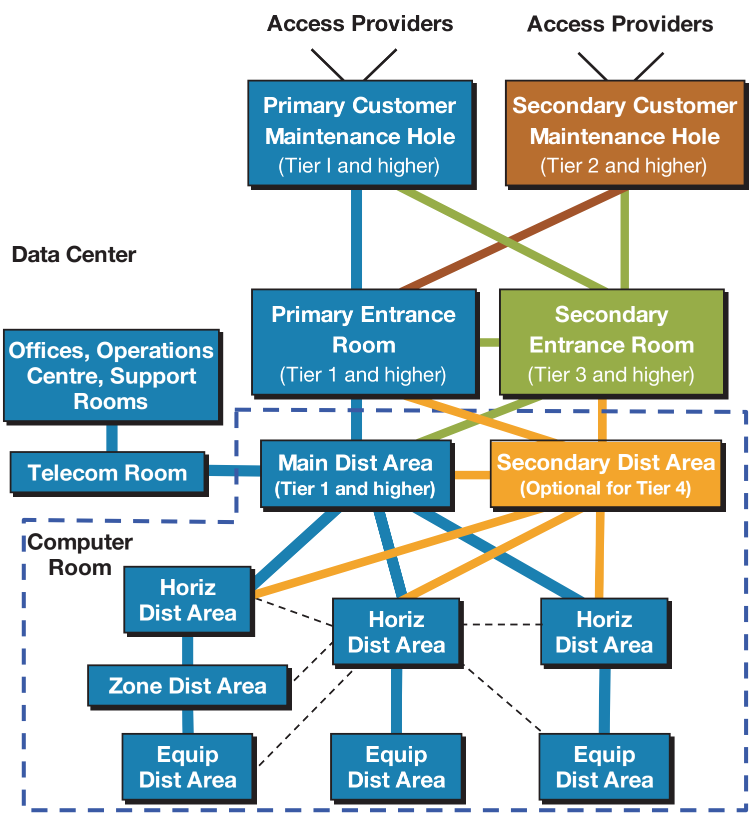
- TIA/EIA-942 (SP-3-0092): Telecommunications Infrastructure Standard for Data Centers.
  It includes recognized cabling media
  - ANSI/TIA/EIA-568-B.2.1 Category 6 cable
  - ANSI/TIA/EIA-568-B.3.1 Laser-optimized OM3 multimode cable
  - ANSI/TIA/EIA-568-B.3 Singlemode cable

In Europe, the infrastructure standard for data centers is covered by:

- Draft EN 50173-5:200x: Information Technology – Generic Cabling Systems, Part 5: Data Centers

In International standards, the infrastructure standard for data centers is covered by:

- Draft IS 24764: Information Technology – Generic Cabling for Data Center Premises



Data Center Topology with Redundancy

Overall, the bulk of cabling is comprised of the interconnection between the individual servers, mainframes, tape and disk storage and the aggregation switches, and from these switches to the backbone switches and out to the Access Provider networks. The cabling model within the main computer room includes connections between, and within, the following areas:

The Main Distribution Area (MDA) is the hub of the cabling system and is located inside the computer room. MDAs act as collection points if a data center resides on several floors. NOTE: In a multi-tenant environment, the MDA may be in a segregated area for security. The MDA includes the main cross-connect and may include horizontal cross-connects if the equipment they serve is nearby (see HDA). The MDA may hold the core routers and the core LAN/SAN switches. Sometimes, service provider equipment (such as multiplexers) is housed in the MDA so that specified circuit distances are not exceeded.

The Horizontal Distribution Area (HDA) is where the horizontal cross-connect resides if the data center is relatively large. In smaller data centers, the HDA is incorporated into MDA. Like the MDA, the HDA may be segregated for security. It includes the LAN/SAN switches and any Keyboard/Video/Mouse (KVM) switches for the equipment.

A Zone Distribution Area (ZDA) is used in large computer rooms that need additional configuration flexibility between the HDA and the equipment.

The Equipment Distribution Areas (EDA) are the racks and cabinets that hold the computing and storage equipment, or may be the tape silos, disk storage units or mainframe computers.

Data center environments lend themselves to fiber optic cabling as the main communications medium of choice for large parts of the DC including the Storage Area Network (SAN), mainframe, switch and tape/disk drive connectivity, with copper cabling as the common local equipment connection such as in the Network Attached Storage (NAS) areas of the data center.

Advantages of a Fiber Optic Network

There are many compelling reasons to choose optical fiber for a data center cabling network.

Increased bandwidth - the ability of fiber to deliver data rates spanning across the full range from kilobits to megabits to multiple gigabits per second and beyond. Providing this range makes fiber the most future-proof media available.

Optical fiber provides broad **applications coverage**. Fiber is a native media to virtually all data applications and in particular for high speed storage applications, with products available from a large number of vendors. Popular high speed LAN applications like 100BASE-FX, FDDI, 1000BASE-X, ATM, and the 10GBASE-X all have standard fiber interfaces. Fiber is also a standard media for high-speed mainframe computer communication specifications like Fiber Channel, Serial HIPPI, and IBM's ESCON® (Enterprise System Connection Architecture). In addition to LAN and mainframe coverage, fiber easily supports single and multi-channel audio/video applications.

Fiber solutions offer enhanced **administration** in the data center as its low loss allows properly engineered fiber cabling designs to use more cross connects. In fact, fiber's distance and bandwidth capability allow most buildings to be cabled with multiple cross connects and still fall within high speed application' power budget constraints. This flexible administration architecture allows switches, servers and other devices to be densely distributed and connected via multiple paths providing efficient and effective redundancy and reliable administration.

The ability to deploy denser cross connects and reduced cable size also **reduce maintenance** activities and cable pathway congestion.

Large operating margins, immunity from radio frequency interference and power surges, and robust cable designs give fiber networks **increased reliability**. Despite its lightweight and small diameter, fiber cable's tensile strength and crush resistance far exceed other cabled media. This robustness reduces the chance of damage during installation and network reconfigurations. Better network reliability results in higher productivity and fewer disruptions.

Optical fiber's low loss and high bandwidth allow your network to cover **long distances**. LAN standards specify multimode fiber links with distance capability sufficient to cover most data center wide networks. For longer distances, singlemode fiber and electronics commonly deliver signals up to 10 kilometers. Within a single building, the high bandwidth of multimode fiber allows multi-gigabit data rates and streamlined architectures with flexible, easy to configure administration.

The increased reliability of fiber networks makes them the right choice for areas of the data center with **mission critical communications**. As additional insurance against network outages, you can design fiber networks with redundant electronics and alternate cable routes to bypass the point of failure.

Fiber networks have no **electromagnetic compatibility (EMC)** concerns. Because fiber transmits information with light instead of electricity, it is not susceptible to radio frequency interference. Lastly, the non-conductive nature of fiber eliminates grounding concerns on data communications cables. In data centers, there is considerable power and heat produced by power generating equipment and the equipment they serve such as switches and servers. Heat can cause increase in insertion loss in metallic communications cables. Large ground potential difference can occur if power is supplied from two different sources (can be true when considering Tier 3 or 4 data center designs for redundancy). In this case, fiber provides a good and safe solution.

Cable Requirements in Data Center Applications

Data center installations require strong, durable cables that can withstand the hazards found in today's data center environments. The multi zone environment common to data center facilities can also place significant physical demands on cables. Cables that are lightweight, have high pulling strength and flexibility, and have appropriate fire ratings and crush resistance may all be required in various areas of the same complex. Some sites require cables optimized for the computer room, a run through high temperatures, and even possibly a run through a rodent infested or flood risk environment between buildings. Multimode and/or singlemode fiber optic cables are available in a wide variety of designs to meet a diversity of requirements. These cables have excellent attenuation and bandwidth characteristics.

Optical cable generally consists of two main components: the core, which contains the fiber; and the sheath, which protects the core. SYSTIMAX® cables are designed to provide excellent mechanical protection against impact, crush, and abrasion. Cables can be configured with various combinations of multimode and/or singlemode fibers.

Choosing the Right Fiber Type for Data Center LAN Applications

When deciding to install optical fiber in data center buildings, one of the design considerations is the type of fiber to use. Should you install singlemode, multimode, or both types of fiber? Usually a few key issues guide the choice. The intended applications support, distance, data (baud) rate, and the difficulty and expense of retrofitting at a later time are all primary considerations. For example, 62.5 micron multimode fiber has historically been the fiber choice for ESCON, its associated Director switch networks and some other SAN applications and therefore may still be required in areas where mainframes are predominant, whereas most modern SAN and LAN applications use 50 micron multimode fiber. Other applications such as FICON® (Fiber Channel Connection Architecture) require singlemode connections, and tape and disk storage may use anyone of the fiber types depending upon their interface.

Multimode Fiber Optic LAN Coverage -

Which fiber is better: 62.5-micron or 50-micron multimode fibers? The answer depends on the parameters of the network: the applications the network will need to support over the next few years and the length of the links. It also depends on whether you are evaluating fiber for a new installation or planning to upgrade from an installed base.

The good news is that both types of multimode fiber traditionally available offer the bandwidth to support such protocols as Ethernet and FDDI over the distances specified in the application standards. Both multimode fibers have proven performance over decades of use. Physically, these fibers have the same cladding diameter and virtually identical mechanical properties. Operationally, the fibers provide similar bandwidth at 1,300 nm. The standards bodies accept both fibers, and both offer migration paths up to gigabit-level speeds. However, there are some important differences that affect the migration paths to higher speed and distance goals.

In terms of performance, the difference lies in the fibers' bandwidth, or information-carrying capacity, and in the power-coupling efficiency to light-emitting-diode (LED) sources. The bandwidth needed to support an application depends on the data rate. As the data rate goes up (MHz), the distance that rate can be transmitted (km), goes down. Thus, a higher fiber bandwidth can enable you to transmit at higher data rates or for longer distances. Current traditional 50-micron multimode fiber offers more bandwidth (500 MHz-km) than FDDI-grade 62.5-micron fiber (160 MHz-km) at 850 nm. However, the smaller core of 50-micron fiber can cause a reduction in power budget for LED-based applications.

Today, the 850-nm operating window is increasingly important, as low cost 850-nm lasers such as vertical-cavity surface-emitting lasers (VCSELs) are becoming widely available for network applications. VCSELs offer users the ability to extend data rates at a lower cost than long-wavelength lasers.

Futureproofing the Data Center Backbone for 10 Gb/s and Beyond

10G Ethernet (10GbE) solutions have been established for combinations of distance and fiber type. These different distance targets allow for optimization of the cost and complexity of the optical components to best serve the needs of the customer environment. This optimization allows the customer to select the lowest cost technology that fits their needs.

There is an option supporting the traditional 50 and 62.5 micron fibers to support 10 Gb/s over 300 meters using WDM type technologies in the 1300 nm wavelength region. There are several options supporting singlemode fiber over various extended distances. And finally, there is an option supporting the Laser Optimized type multimode fiber (LOMMF/OM3) developed to support short wavelength (850 nm) 10 Gigabit/second applications. Short wavelength LAN electronics have historically been significantly less expensive than long wavelength equivalents. Since LAN electronics make up the largest part of total LAN costs, these savings are significant. Even though Laser Optimized multimode cabling system may cost slightly more, costs are far less for a short wavelength 10 gigabit system when compared to a long wavelength multimode or singlemode systems.

The question does not therefore come down to a choice between singlemode or multimode, 50 or 62.5, it should be looked at from an application and distance standpoint, and the full capabilities of the fiber in question.

Singlemode LAN Coverage -
For the longer distance requirements or specific applications such as FICON, singlemode fiber provides the LAN solution at these higher rates. Singlemode fiber provides a near-perfect complement to multimode fiber for extended backbone links. Where multimode capability falls off, singlemode solutions are readily available.

Install both Multimode and Singlemode -
With the benefit of the preceding perspective, it is recommended to deploy Laser Optimized multimode fiber in the backbone and horizontal segments of the data center. It is also generally recommended to install singlemode fiber in backbone segments. This combination will most cost-effectively support present day applications as well as provide future proofing for tomorrow's higher speed LANs and broadband video. Of course these recommendations must be weighed against the application and planning horizons of each customer.

Connector Requirements in Data Center Applications

Data center installations require rearrangeable and consistently reliable connections that are also protected in environments having high density. As with the type of fiber already discussed, different connectors have emerged over the years based on the different equipment used in the data center, such as ESCON and MT-RJ connections. However for the infrastructure it is recommended to select the best performance connectivity to allow for future high-speed applications, and optimize density. Hybrid connection can then be used to connect to specific equipment.

The recommended connectors are the LC for applications using simplex or duplex connections, and the MPO connector for parallel or multi fiber applications.

Cabling Architectures and Design Considerations for the Data Center Environment

The right architecture is one that meets the needs of the particular organization's network in the most efficient way. Many issues must be addressed when choosing a data center cabling design. Among them are the structure of the data center network, it physical layout and the way the building is occupied. Others involve considerations about the LAN services required now and into the future.

For the design of the cabling system in a data center environment, the two main sub systems are the Data Center Backbone and the Data Center Horizontal, that connect the Main Distribution Areas to the Horizontal Distribution Areas and on to the Equipment Distribution Areas.

Data Center Backbone
The data center backbone level is the primary infrastructure of the data center plant cabling. The data center backbone comprises of a fiber optic segment series and cross-connects configured such that there should always be physical redundancy of fiber optic cable. In addition, the fiber optic cables must also be diversely routed to enable secure redundant paths. The data center backbone provides highly reliable physical connectivity for critical applications.

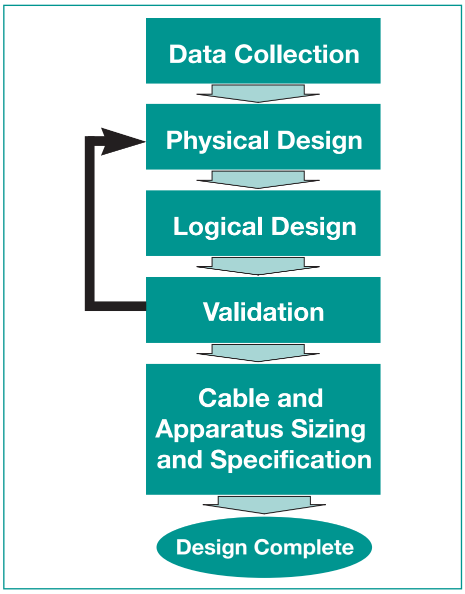
The redundancy of the data center backbone addresses the high reliability requirements in the data center environment by always offering an alternate and diversely routed path for communications. In the event of a cable or equipment failure, traffic can be rerouted via a manual patch or rerouted automatically with active electronics.

Data Center Horizontal
The data center horizontal is the cabling and associated cross-connect hardware and faceplates that provide connectivity to end point equipment with or without alternate or diverse routing. The physical topology of the data center horizontal is a star or hierarchical star. The data center horizontal follows many of the standard office design guidelines, but is different in that connections are from patch panel to another patch panel or some form of multiport panel in the mainframe cabinet enclosure for example.

The media of the data center horizontal may vary. It may consist of fiber or UTP. The media selection is dependent on the environment and the application.

General Design Considerations

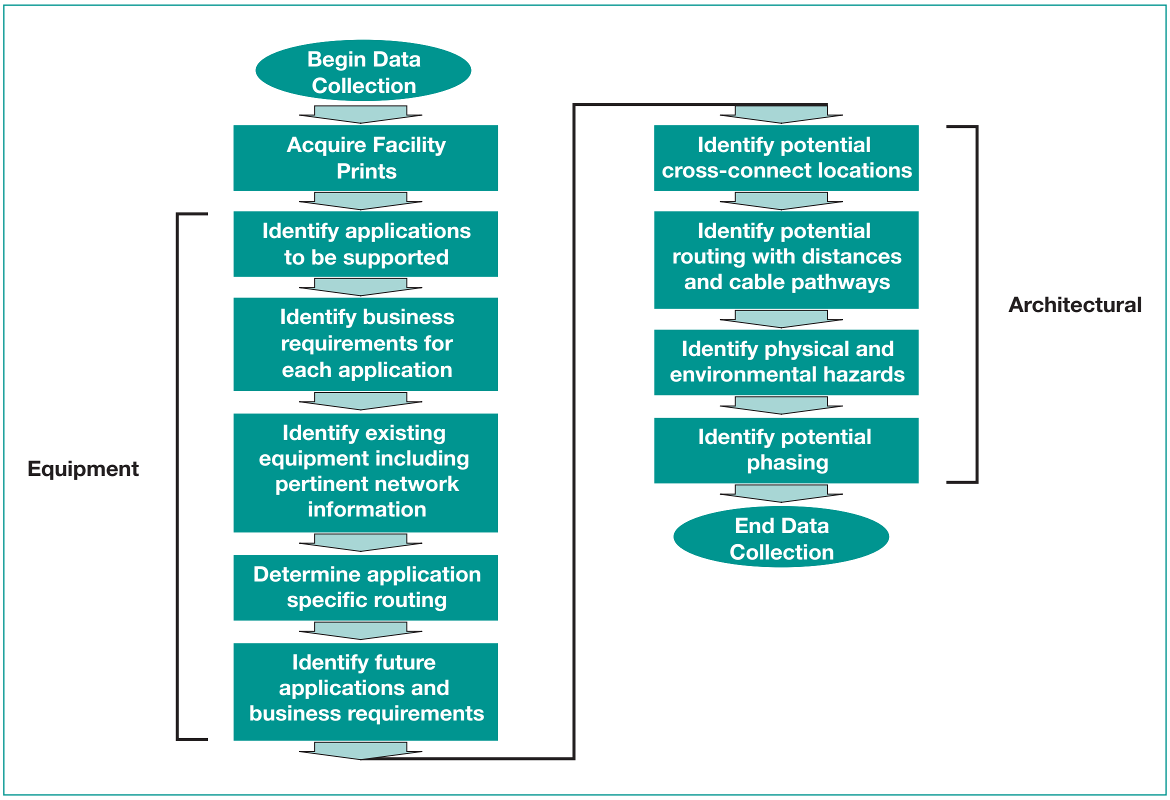
Each data center site has its own unique requirement and the level of connectivity from one site to another varies dramatically. However the design architecture should be consistent among all installations and the process should follow the following procedure:



Data Collection

A cabling system for the data center environment may be designed with specific requirements in mind or to provide a 'generic' distribution system for a facility. In the first case a significant level of detail should be available regarding the types of devices to be connected and their associated interface requirements. For a 'generic' design, only architectural and environmental information may be available. In either case, the first step in developing any design is to collect as much information as possible about the site.

The end result of the data collection process should include a complete facility layout with potential node locations identified and all equipment locations, quantities and reliability requirements marked. In addition, a table listing the point-to-point connectivity requirements for each type of communications interface and type of equipment must be developed in this step.



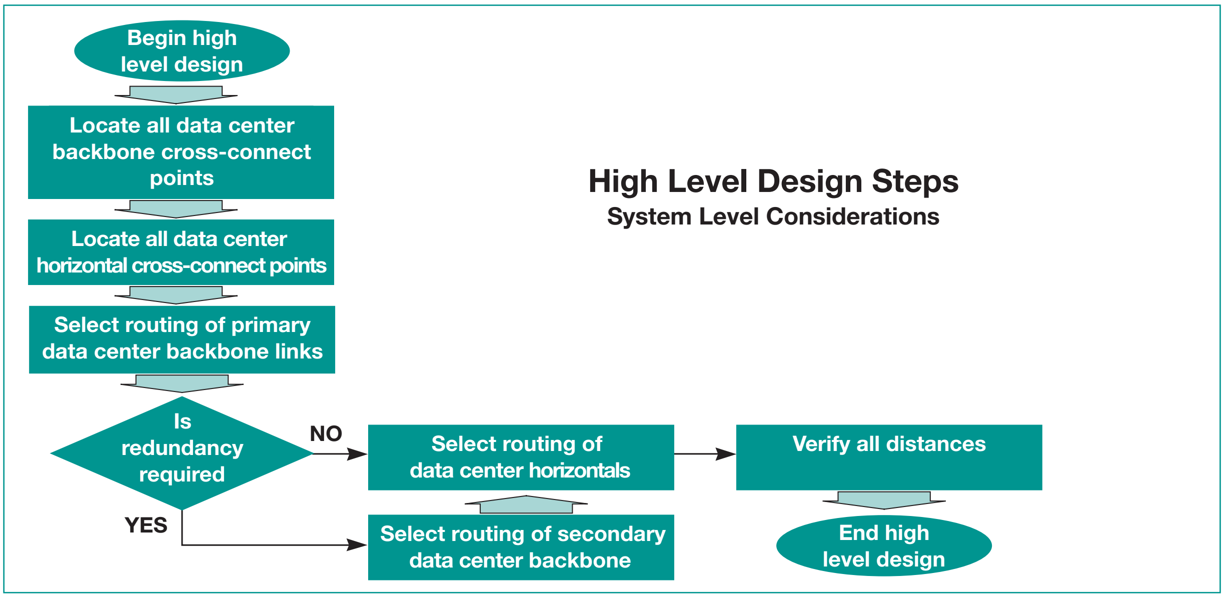
Physical Design

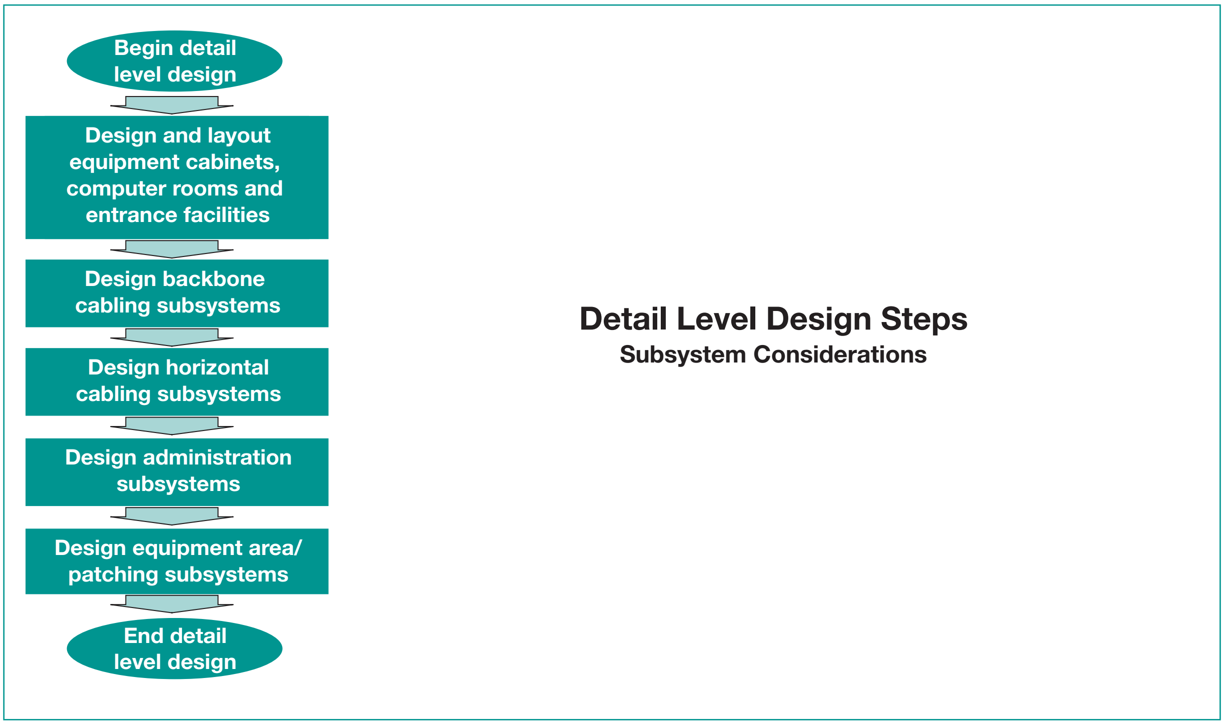
Physical design for the cabling system can be divided into two levels: high level design and detail level design. The high level design addresses issues related to locating and routing the backbone and horizontals while the detail design addresses issues relating to the subsystems such as the exact location and number of cross-connects, size of cables, number of patch cords etc.

Since the design of a cabling system is an iterative process the high level design is completed first, followed by the detail design.

The data collected in the data collection phase should be used at this point. The overall facility drawing with potential node locations marked should be used to lay-out potential data center backbone routes. In many cases this can be done by 'connecting the dots' representing potential node locations identified during earlier walkthroughs. This process is the same whether this is an existing facility or a new building or plant.

The preliminary routing should then be reviewed to ensure that the design rules are satisfied. For example, if the backbone doesn't allow redundant paths depending on the reliability level required, potential redundant routes should be identified to complete this. The distance between the nodes and the main equipment room should be assessed depending upon the application to be supported. The final result should be a backbone cable route connecting all critical points within a building with redundant paths.





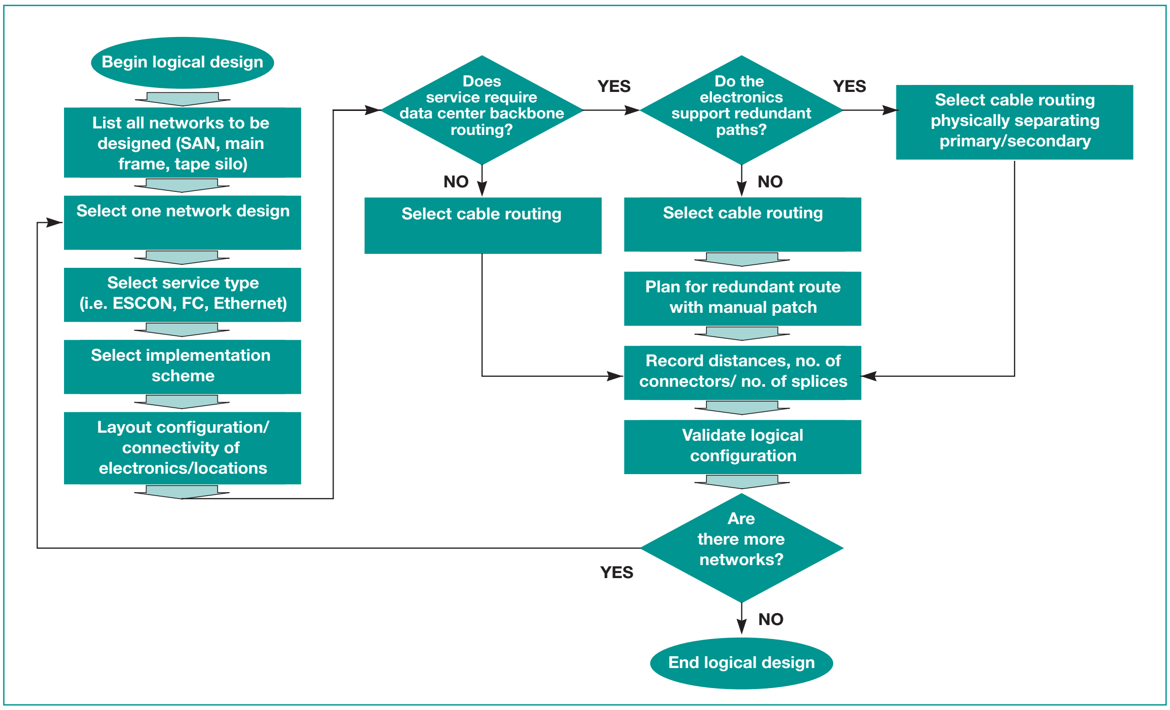
In the data center backbone, all single point administration end-to-end links including patch cords using multimode fiber are recommended not to exceed 300 meters (984 feet) in length. In the data center horizontal, home-run cables should not exceed 90 meters in length.

For all single point administration architectures sufficient cable slack shall exist in the closet or cable pathway to allow any necessary movement of the cables when migrating or changing a horizontal cross connect. Slack may be stored as cable or fiber. Slack storage shall provide bend radius control so that cable and fiber bend radius limitations are not violated. Cable slack may be stored within enclosures or on the walls or cable trays of the closet. Fiber slack (buffered or coated) shall be stored in protective enclosures.

Logical Design

The logical design considers the applications and services required in the facility. This part of the design may not be possible in a 'generic' design, but some level of expected applications and equipment should be assumed. The following are some rules of thumb to be considered:

- Maintain protocols in native format
- Select electronics which support industry standards
- Keep separate networks/service types on separate fibers
- For topologies that support secondary cable routes, separate primary and secondary paths when routing over the data center backbone
- For critical applications on the data center backbone that do not support secondary cable routing, plan redundant rerouting via manual patch



Validation

Design validation should be performed to ensure that all designs meet certain parameters, for both the physical and logical requirements. The physical validation should be based on application requirements, distances and redundancy requirements. Both singlemode and multimode should be installed as standard. Multimode cable segments should be limited to 300 meters where possible to ensure high speed applications can be supported.

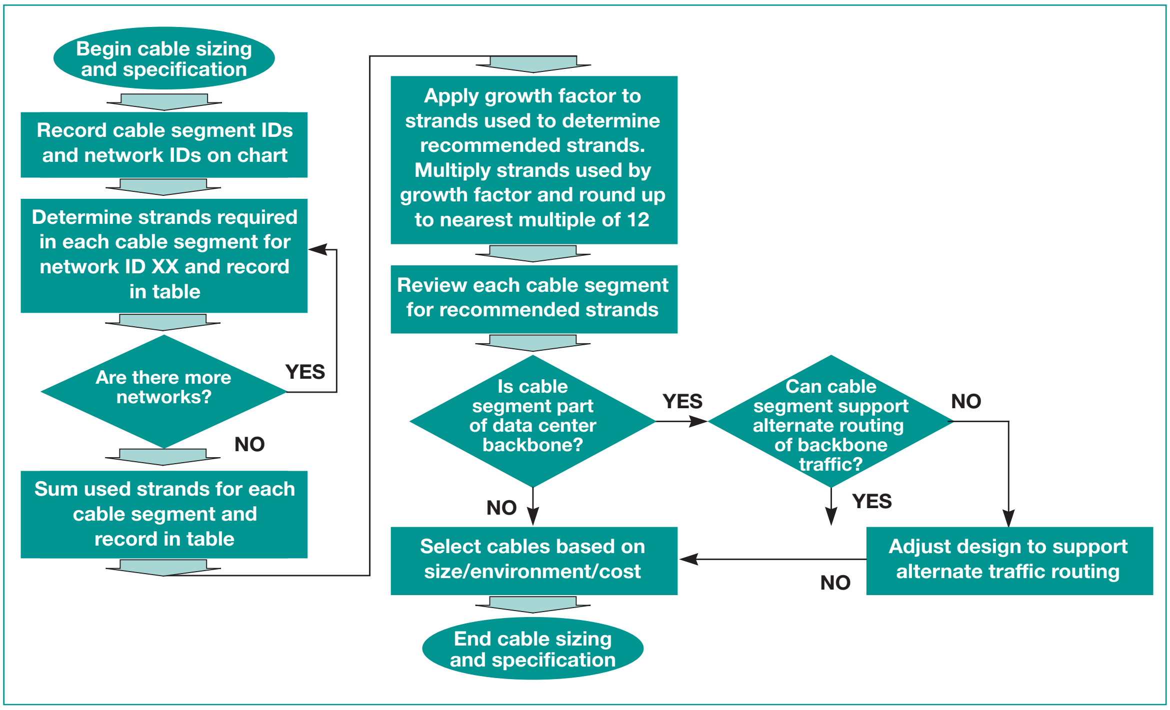
The logical validation pertains to the selection and configuration of electronics and services over the physical cable plant. Whenever there are standards for a particular service or protocol, always validate against this standard. When proprietary protocols are involved, vendor specifications are used for validation. The following is a list of issues that are usually addressed for the logical validation:

- Optical parameters (wavelengths, source types etc.)
- Basic configuration
- Power margin analysis
- Channel loss calculations
- Distance between electronics
- Timing considerations
- Number of stations
- Total length

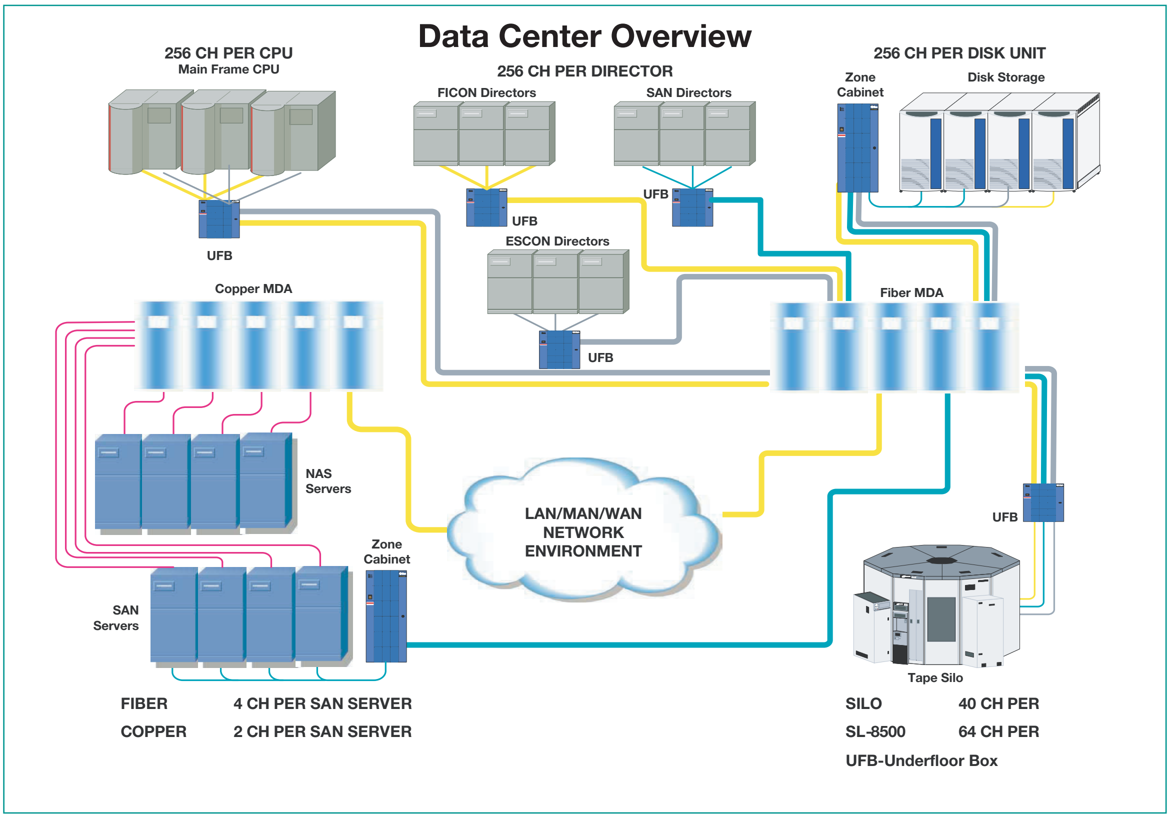
Cable Sizing and Specification

When sizing and selecting cable the following rules of thumb are useful. They are only guidelines. Since each data center site has its own unique characteristics, a detailed data collection and design process is required.

- A growth factor of up to 50% is often applied after sizing current application connectivity
- Factors affecting data center backbone cable sizing include:
  - Application channel requirements
  - Data center layout
  - Data center size (number of buildings)
  - Level of density (amount of computer connectivity)
  - Level of redundancy
- Cable type selection is based on environment and cost
- Use a mixture of singlemode and multimode fiber optic



Connectivity Examples in the Data Center



(Courtesy of Sun Microsystems)

- **Tape Silo Units** hold up to 40 drives and newer horizontal units hold up to 64 drives, drives have two channel interfaces for redundant connectivity, both units are scaleable and can be connected to other units. (MPO interface is common).
- **Disk Storage Units** are typically scaleable up to 256 channels and larger. (LC interface is common).
- **Director Switches** are large high performance scalable SAN, FICON or ESCON switches deployed at the core. Directors are Typically Scaleable to 256 Channels Connections or more. (Interface will vary upon application).
- **Data Center Server Farms** include email servers, file servers, web servers, application servers, database servers, remote access servers, telephony servers, terminal servers, etc. Servers typically have multiple connections (i.e. SAN/NAS servers typically have 4 fiber storage connections and two copper network connections on alternate paths) (LC and RJ45 interfaces are common).
- **Mainframe CPU** connectivity is typically 256 channels per CPU. (MPO interface is common to CPU, with harnesses connecting to MT-RJ or ESCON interfaces on the equipment).

Data Center Cabling Selection

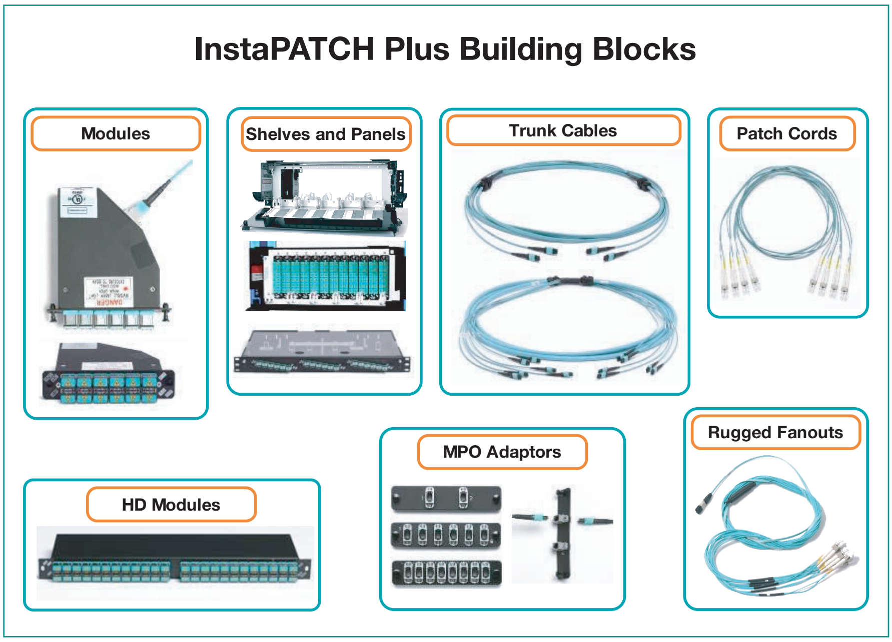
The cabling architectures used for data center structured cabling systems, require a mix of **High Density, High Reliability, High Performance, with Flexible Design Guidelines, Speed of Installation, Future-Ready and Easy to Use.**

SYSTIMAX LazrSPEED® and TeraSPEED™ Solutions are the ideal **Data Center Backbone** solutions, with the SYSTIMAX LC connector offering superior loss and density in the data center. The SYSTIMAX InstaPATCH® Plus Solution offers additional benefits such as fast, reliable installation, flexibility, high density and ease of moves and changes. The iPatch® Solution offers additional benefits such as flexibility, manageability, security and high density.

The SYSTIMAX GigaSPEED® X10D Solution, combined with the LazrSPEED Solution, is the ideal **Horizontal Cabling** solution, delivering flexible design configuration and high performance.

The SYSTIMAX InstaPATCH Plus System utilizes MPO array fiber connectors for plug-and-play connectivity. The InstaPATCH Plus System is intentionally flexible in its implementation of array fiber technology, component design and component portfolio to allow network designers almost infinite network topology options. The InstaPATCH Plus Solution allows fast, predictable, and easy installation of high density fiber solutions, a common requirement for data center projects. The ribbon fiber cables and MPO connections, coupled with the unique polarity features of the InstaPATCH pre-configured high density patch panels, allow fiber networks to be deployed effectively onsite in less time, plus providing the necessary density created by grouping many server connections together.

When the IT department needs rapid deployment or re-arrangements combined with the ability to support high density fiber-based duplex applications today AND parallel applications in the future, the InstaPATCH System featuring LazrSPEED OM3 fiber technology is the optimal choice. The InstaPATCH System features a high-density, factory-terminated and tested, modular fiber connectivity solution that allows installers to connect system components together simply and quickly. The system is comprised of shelves, panels, modules, and trunk cables with 12-fiber Multi-fiber Push-On (MPO) connectors providing instant terminations and LazrSPEED multimode fiber technology capable of delivering 10G support.



This modular approach enables 96 fibers to be ready for service in about 10 minutes, or the same time it takes to make a single fiber connection with other systems. Traditional field termination would take 16 hours (two man-hour days) for 96 fibers.

InstaPATCH pre-terminated trunk cables are offered in customer-specified lengths with LazrSPEED, OptiSPEED or TerasPEED fiber in a 12-fiber or 2x12-fiber cable construction. 12-, 24-, and 72-fiber cables are also available in a round cable construction with pre-terminated 12-fiber ends. There is also a “pulling eye” option to all InstaPATCH trunk cables to improve the installation process even more.

Benefits for data center designers include ease of installation for today while providing a simple cost effective migration path for higher bandwidth in the future. Current deployment involves serial array connectivity utilizing trunk cables with multi-duplex fan-outs that maintain polarity between send and receive signals via keyed mated connections. However, tomorrow’s mainstream application will move to full parallel and deliver increased bandwidth over multiple channels. The InstaPATCH Plus System is engineered to anticipate this transition. To move from serial to full parallel, it is a simple process to remove the duplex modules, insert the MPO-only modules and attach additional trunk cables to the network equipment.

The SYSTIMAX InstaPATCH Plus Modular Fiber System more than meets the requirements of today’s evolving data centers, including high density and reliability, high performance, high quality in an engineered system that offers a flexible design and ease of installation and use. Data center designers and managers faced with challenges in maintaining critical operations while implementing strategies for evolving to a more efficient converged platform of resources, can rely on SYSTIMAX Solutions™ comprehensive portfolio of advanced cabling solutions that allow IT departments the freedom and flexibility to deploy dynamic designs for their physical layer infrastructures to meet unique data center requirements.

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