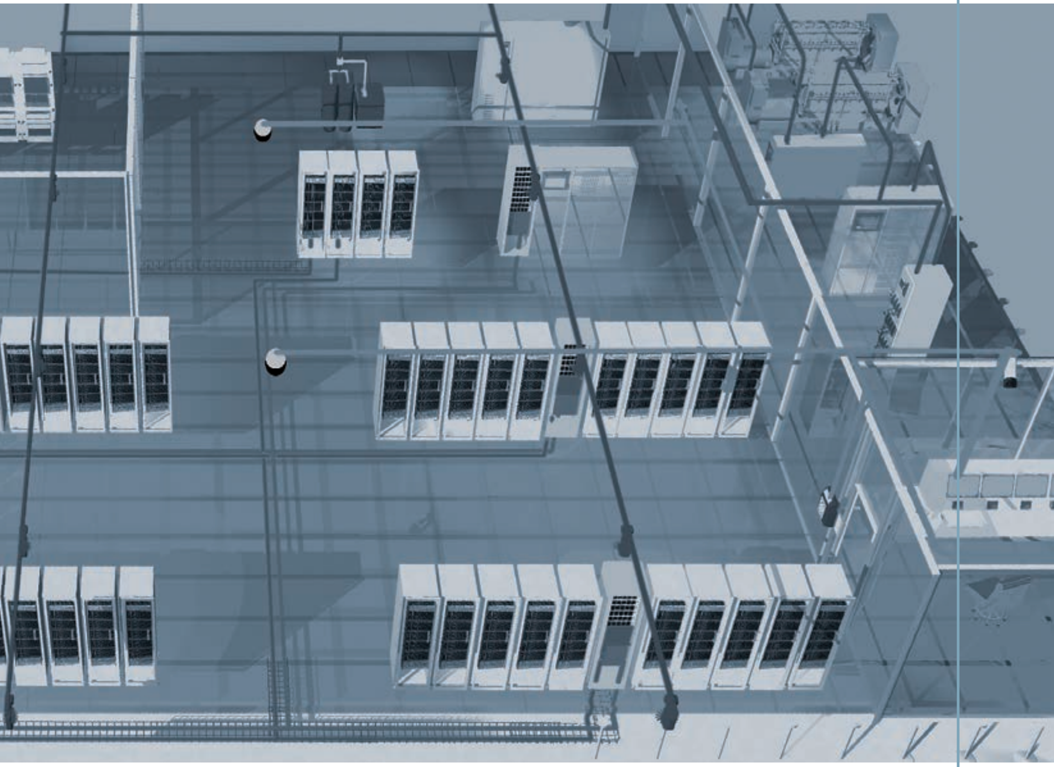
Data Center Infrastructure Resource Guide



ANIXTER

Anixter is a leading global supplier of communications and security products, electrical and electronic wire and cable, fasteners and other small components. We help our customers specify solutions and make informed purchasing decisions around technology, applications and relevant standards. Throughout the world, we provide innovative supply chain management solutions to reduce our customers' total cost of production and implementation.

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INTRODUCTION

What is a Data Center?

Data centers are the "nerve centers" of the new economy or special environments that house the latest advances in computer processing and business innovation. Data centers centralize and consolidate Information Technology (IT) resources, enabling organizations to conduct business around-the-clock and around the world.

A data center is a "hardened" facility that is dedicated to providing uninterrupted service to business-critical data processing operations. Among its many features are:

- 7 x 24 x 365 availability
- Fail-safe reliability and continuous monitoring
- Power management and network communications, redundancy and path diversity
- Network security, physical access control and video surveillance
- Zoned environmental control
- Fire suppression and early warning smoke detection systems.

TYPES OF DATA CENTERS

Data centers fall into two major categories including corporate data centers (CDCs) and Internet data centers (IDCs).

Corporate data centers are owned and operated by private corporations, institutions or government agencies. Their prime purpose includes supporting data processing and Web-oriented services for their own organizations, business partners and customers. Equipment, applications, support and maintenance for the data center are typically supported by in-house IT departments or contract partners.

Internet data centers are primarily owned and operated by traditional telcos, unregulated competitive service providers or other types of commercial operators. Each operator, however, involves similar goals—to provide outsourced Information Technology (IT) services accessed through Internet connectivity. Their business is to provide a menu of services to their clients. These services may include (but are not limited to) wide-area communications, Internet access, Web or application hosting, colocation, managed servers, storage networks, content distribution and load sharing with new variations appearing almost daily.

In many ways, IDCs present an alternate model for Internet connectivity and eCommerce. IDCs are particularly attractive to new or small-to-medium businesses that have yet to invest money in IT or simply want to pay for what they use.

THE RECENT SURGE IN DATA CENTER ACTIVITY

The emergence of the Internet as a universal network, the Internet Protocol (IP) as a common computer "communication standard" and the continued advancements and maturity of Web technology have served as catalysts for a number of common business initiatives. These initiatives include:

- Server consolidation and centralization of processing capability
- Business system continuity and disaster recovery
- Database content and storage management
- "Webification" of business applications
- Information distribution via Intranet and Extranet
- eBusiness and Electronic Data Interexchange (EDI)
- Supply Chain Management (SCM) and Enterprise Resource Planning (ERP)
- Customer Relationship Management (CRM)
- Sales Force Automation (SFA)
- Wireless applications and connectivity.

Another factor contributing to the surge of data center construction is the increase in the number of Internet connected devices per business or household. Often times, data centers are expanding well beyond the number of actual users. Business professionals are adopting wireless PDAs (Personal Digital Assistants) in addition to or within their cell phones. Residential customers often have multiple PCs, wireless networks and a growing comfort factor with the Web as a shopping mall, Yellow Pages and eLibrary. Consequently, a "many-to-one" device-to-user ratio is driving the need for additional network connectivity and data center expansion.

Additionally, bandwidth capacity and availability are increasing while monthly access charges are decreasing for wide area, metropolitan and residential services. Web resources must also increase in order to meet the market demand for higher performance and availability.

CDCs are also expanding and modernizing to meet the growing demands of mobile professionals, as well as supporting rapid new customer acquisition and enhanced service initiatives. IDCs continue to sprout up around the world to capture market share in the online business and consumer service market.

SAME ISSUES, DIFFERENT SCALE

Corporate data centers and Internet data centers share many common attributes and vary mostly in terms of scale and user base served. Most corporate data centers provide connectivity, application services and support to hundreds (or thousands) of workers within a building, campus or remote company facility. Internet data centers are like 21st century commercial versions of a telco central office. Instead of merely providing dial tone, these IPCOs (IP Central Offices) provide IP services over which customers may opt to run voice and video along with their data. The IDC model employs the Internet as an international "network of networks," traversing many, if not all, traditional telco service areas. The challenge is to provide users with the reliability and performance they have come to expect from their traditional voice providers.

IDCs will continue to implement greater levels of redundancy and diversity of data paths, including power, transport, cabling infrastructure and networking hardware. Because IDC business plans revolve around economies of scale, the more services sold per square foot of real estate causes density to reign. This often leads to unique issues not always found in the private data center environment.

COMMON ATTRIBUTES OF DATA CENTERS

There are many common functions in data centers today—whether they are owned and operated by corporations or leased from an Internet data center operator. For the most part, all data centers require:

- Internet access and wide area communications
- Application hosting
- Content distribution
- File storage and backup
- Database management
- Failsafe power
- Adequate heating, ventilation and air conditioning (HVAC) and fire suppression
- High-performance cabling infrastructure
- Security (access control, video surveillance, etc.)

SECTION 2
Data Center Design Considerations

PROFESSIONAL ENGINEERING

With so many electrical, mechanical and communication variables involved, successful data center design and construction begins with professional engineering. Data centers are unique environments; developers can benefit from the architect, engineering and consulting community, along with construction firms with experience in designing and building data centers.

Internet data centers have additional requirements that are not always as critical in a private environment or may simply be implemented in a different way. Requirements for cooling and spacing may differ by data center design.

Some of the benefits provided by professional engineering include:

- Familiarity with the trades involved in a project (HVAC, electrical and mechanical)
- Coordination of the many trades involved in the building process
- Telecom and datacom expertise
- Unbiased written specifications based on performance
- Understanding clients' network demands
- Meeting state licensing requirements
- Assuming professional liability for design and operational problems.

Once data centers are up and running, they have zero tolerance for downtime and other problems caused by poor design or flawed installations. Careful thought and consideration must be put in the data center design phase.

POWER REQUIREMENTS

As recent as five years ago, planners could rely on tried and true rules of thumb to plan for an adequate amount of power for a data center build-out. However, the staggering pace of technological advancements (especially with servers, switches and storage devices) have combined to completely change the landscape for data center power consumption. As an example, during the five years between 1998 and 2003, data center power consumption doubled in the U.S. Even more remarkable is that this consumption doubled again in the three years between 2003 and 2006 as reported by the U.S. Department of Energy. Since 2003, the increasing acceptance and deployment of blade and 1U (single rack unit) servers are resulting in a power consumption density at the cabinet level that drastically changes the traditional rules of thumb designers relied on for more than 15 years. Today, the pace of power consumption continues to rapidly increase in data centers. As a result, in late 2006, the House and Senate passed bills that tasked the Environmental Protection Agency with how to reduce the pace of power consumption in data centers.

Along with power consumption, data centers are also expected to operate without downtime. One of the ways to help data center managers achieve their company's availability objectives is to design redundancy into the data center infrastructure. As the demand to be operational increases, often it is necessary to duplicate components that make up the data center infrastructure, either to allow for planned maintenance or to protect availability from unplanned failures. At the upper end of availability requirements, multiple power grids are funneled into a single data center to provide assurance that there will always be power available to run the facility.

Thanks to the efforts of the Uptime Institute and other standards resources, most active component manufacturers today build their components with dual (sometime triple) power supplies. Multiple power supplies allow a component to have power delivered to it from multiple power sources and pathways.

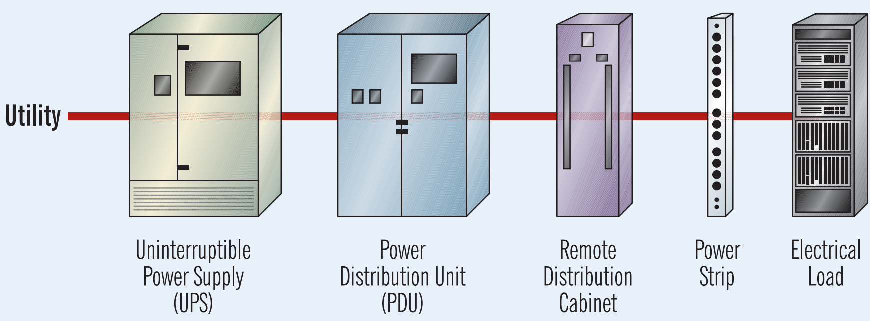
In conjunction with the increasing amount of power in data centers, it is also becoming more critical to build a solid electrical grounding grid to protect the equipment and the personnel. See ANSI/-J-STD-607-A or CENELEC EN50310 for more information.

While the traditional rule of thumb for data center power planning has typically been expressed in "watts per square foot," availability conscious data centers are adopting "watts per cabinet" as their new rule of thumb for power planning. In addition, as data center managers migrate toward either Tier 3 or Tier 4 availability (as referenced by the Uptime Institute, see page 36), they are constantly looking at ways to create redundancy in their infrastructure. This is especially true of data centers that are required to operate all day, every day. Without redundancy, data centers would have to shut down the systems to perform routine maintenance.

Even though redundancy in the infrastructure allows continuous operation of the data center, it creates significant problems at the cabinet level. Redundant power supplies require twice as many power cables and power strip outlets. Multiple communication pathways increase the number of data cables outside of the cabinet.

In addition, as the power and thermal densities increase at the cabinet level, it is increasingly important that management and monitoring systems are added to the cabinet and the data center. The systems that are available today provide complete coverage of the environmental and component operation at the cabinet level, as well as for the entire data center. Typical systems can be configured to monitor temperature, smoke and humidity, as well as power consumption, fan status and UPS operation. Many of the latest systems also offer access control and video surveillance options. (This topic will be covered in greater detail in Section 3.)

Basic Power Distribution System



COOLING

The steady increase in acceptance of blade and 1U servers has created a significant challenge to provide adequate cooling for high-density equipment cabinets. In addition, cabinet manufacturers have recently introduced cabinet designs that address cable management and heat dissipation. Today, it is not uncommon for a full cabinet of blade servers to consume over 20 kW of power and to produce over 20 kW of heat.

Along with the new thermally sensitive cabinet designs, there is also a great deal of product development work being done to enhance the cooling capabilities of new and existing data center air conditioning systems.

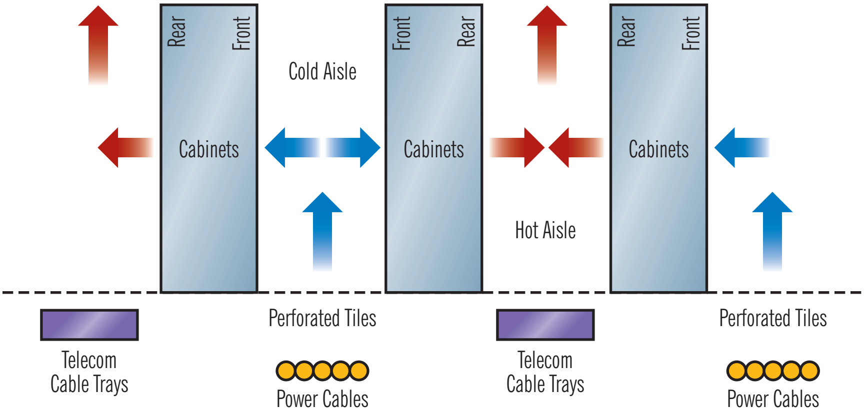
As recommended by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the ANSI/TIA-942 data center standard, the first step to gaining control of excess heat is to reconfigure the cabinet layout into a hot aisle/cold aisle arrangement.

According to the recent ANSI/TIA-942 data center standard, when a raised floor is used to provide equipment cooling for the data center, the minimum aisle width should be at least three feet. Typically, cold aisles are four feet wide to allow for two fully perforated floor tiles in front of cabinets with active components. Hot aisles should be wide enough to allow for unrestricted access to data and power cabling. Additionally, the standard states that the data center power distribution cabling should be located under the cold aisle and the cable trays for telecommunications cabling should be located under the hot aisle.

In conjunction with the new layout, it is essential to install blanking panels (see Diagram 1) in every open bay, in all cabinets in a high-density area. These inexpensive but effective panels have been shown to greatly reduce the undesirable mixing of hot discharge air with cold intake air. In an attempt to direct hot discharge air into the hot aisle, it is also recommended that solid tops and solid side panels be installed between all cabinets in a row.

Additionally, the installation of air dams in the front of the cabinet is recommended to block hot air from slipping around the sides of the mounted components and mixing with the cool intake air. Finally, ASHRAE recommends that precision sized Computer Room Air Conditioners (CRAC) be placed at either end of the hot aisles.

Hot Aisle/Cold Aisle Cabinet Configuration



Source: ANSI/TIA-942 Standard

Notice the difference in operating temperatures when blanking panels are used. As illustrated in Diagram 1, blanking panels block the pathway for hot air to re-circulate to the intake side of the mounted components. However, blanking panels only block the path between components. Hot air will still re-circulate between the sidewalls of the cabinet and the mounted components as illustrated on the left side of Diagram 1. When air dams are installed (right side of Diagram 1), in conjunction with blanking panels, virtually all pathways, internal to the cabinet, are blocked.

External to the cabinet, it is much more difficult to block hot exhaust air from mixing with cool air on the intake side of the mounted components. Hot exhaust air will still be drawn over the top of the cabinet and around the sides of freestanding cabinets. While it is not always possible, the best way to deny hot exhaust air from mixing with cool intake air is to exhaust it out of the area.

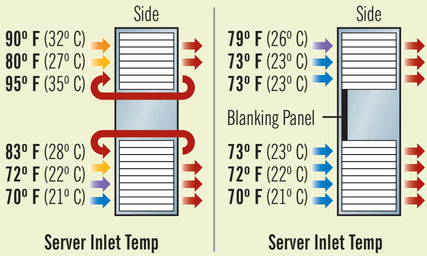


Diagram 1

SPACE ALLOCATION

Where possible, support equipment such as HVAC, UPS battery backup and generators should be located outside of the data center production floor. This will free up valuable space and minimize the number of outside vendors who are allowed in the computing area, reducing the risk of intentional or accidental tampering with critical network equipment.

CABLE MANAGEMENT

Raised floor cooling systems rely on static pressure to push cold air through perforated floor tiles and in front of cabinets where it can enter and cool active components. When data and power cable share the underfloor space, it is essential that cable runs be laid out before CRACs are positioned. Supply air must be delivered in the same direction as cable runs to minimize unintentional air blockage.

Careful consideration must be given to the relationship of air flow and cable runs during the design phase of a project. Cable runs that cross airflow patterns at a 90-degree angle should be positioned so they will not restrict airflow downstream of their position.

While locating cable under the raised floor gives the data center a clean, traditional look, occasional access to the cable may be required to deal with moves, adds and changes (MACs). When floor tiles are opened to gain access to data or power cable, the overall static pressure of the system is diminished. As a result, the volume of supply air across the entire data center is reduced, creating potential overheating problems.

To avoid static pressure disruptions when raised floors are not utilized, it is becoming more common to see overhead cable management deployed. While it changes the traditional look of classic data centers, overhead cable management offers several advantages including easy access and unrestricted airflow.

ACCESS FLOORS

One of the key predesign considerations that affects almost every aspect of success within a data center environment is the access floor, or “raised floor” as it is often referred to. This infrastructure is every bit as important to cooling, equipment support, grounding, and electrical and communications connectivity as the building structure supporting it. When an access floor is chosen as a means to distribute services to the data center, there are many criteria to consider regarding these utilities. Some of these include:

- Seismic and vibration considerations
- Need for equipment to be bolted to and stabilized by the flooring structure
- Positioning of equipment to provide easy access to removable tiles and raceways beneath
- Spacing of access, cooling and maintenance aisles
- Panel strength and airflow requirements
- Electrical bonding and anti-static conductive needs
- Rolling, ultimate and impact load capacities
- Minimum height requirements for easy access.

These environmental conditions will necessarily dictate the choice of stronger grids, panel construction, surface laminates and overall design considerations. As the access floor grid is often one of the first structures in place prior to any cabling or equipment, it is often the victim of harmful disruption. Often, as the cable tray, power or communications infrastructure is laid, the grid is disturbed and “squaring” or stability is compromised, causing numerous undesirable issues to occur. For example, tiles may not fit and grounding may be compromised. The best way to confirm overall success and minimal delay is to spend more time on coordinating professional trades, understanding support equipment, and planning, designing and carefully selecting the access floor material.

SECTION 3

Data Center Infrastructure Considerations

RACKS, CABINETS AND SUPPORT INFRASTRUCTURE

Data centers employ a wide variety of racks, enclosures and pathway products such as cable trays and ladder racking. There are numerous variables to consider when selecting the right product. They must all in some way, individually and collectively, support four key areas. These areas include:

- Climate control, namely cooling and humidity
- Power management
- Cable management
- Security and monitoring.

Configurations vary between CDC and IDC models. In a corporate data center, a typical enclosure might house 12 to 24 servers with a switch and a monitor generating a heat load in excess of 4,500 watts. It is easy to understand how cooling problems can arise in such a scenario. Even with computer room cooling and a fan at the top of the cabinet, there can be a wide disparity in temperature at the top versus the bottom of the enclosure.

Racks and cabinets must often meet seismic (Zone 4) requirements as defined by the Telecordia GR-63-CORE Standard, the Network Equipment Building System (NEBS), as well as load bearing and server depth specifications. These support structures must also provide effective cable management. There are many unique designs and innovative approaches that can help confirm neat, manageable bundling and routing of cables with mechanical protection, stability and flexibility.

Data centers also vary widely in their approach to inter-cabinet or inter-rack cable distribution. Many prefer cable runway below an access floor, while others have adopted an overhead ladder rack approach. Still, others see unique merit in each and use both systems. Overhead ladder rack allows for more convenient access to cables, making moves, adds and changes easier. On the other hand, under floor runway provides more security and cleaner aesthetics though future changes and a blockage of airflow may become an issue.

REDUNDANCY AND PATH DIVERSITY

Redundancy and path diversity are considerations in CDC and IDC environments for power, cabling, Internet access and carrier services. Tolerance for downtime measured against added equipment costs and "support area-to-raised floor" ratios must be closely examined and matched. Based on these criteria, data center developers and operators design and implement different infrastructures. Corporate data centers must carefully weigh the cost of downtime with respect to their revenue model. If outages prevent order entry, particularly during peak conditions or seasonal surges, business management must confirm that IT provides the availability and reliability to consistently meet those demands. In the IDC arena, many operators must strive to meet or exceed the legendary "five nines" of the public telephone network. In a nutshell, "five nines" reliability equates to slightly more than five minutes downtime annually for 24-hour service levels. It is a challenge in the data world to achieve that level of reliability, yet that is the customer expectation. N+1 and 2(N+1)* component redundancy is required to meet these objectives. This desired level of stability creates a cascading effect on capital investment, usable revenue generating floor space versus support equipment space and dollars invested per square foot.

*Note—see page 21 for explanation.

SECURITY

Data centers are the lifeblood of information. Company and customer data should be treated like money in a bank vault. Corporate and Internet data centers must take definitive measures to limit access only to authorized personnel, and confirm use of proper fire prevention and life safety systems while minimizing the potential of equipment damage. Video surveillance (CCTV) and biometric or card access control are often sufficient in CDCs, but in IDCs, where personnel may often come from many different companies (sometimes from the competition), additional security is required. Besides perimeter-type security, compartment security is recommended via locked cabinets or collocation cages, and additional provisions for cable raceway and raised floor access become necessary to achieve customer comfort levels. In addition, real-time personnel and asset tracking may be used.

STORAGE

Storage in both corporate and Internet data centers may migrate to the storage area network (SAN) model over time as the volumes of stored data escalate and the management of content becomes more challenging. Additional or complementary connectivity concerns must be addressed in the data center design to accommodate for flexibility and the most efficient and effective use of space. The use of Fibre Channel technology and 50-micron multimode optical cabling may cause the re-evaluation of overall distribution design. As other data link level transport methods (such as 10 Gigabit Ethernet) are evaluated and/or standardized for use in SANs, there may be an advantage to using the same fiber type to interconnect storage systems and servers throughout the data center.

FLEXIBLE AND ADEQUATE CONNECTIVITY

Adequate connectivity is key to bringing users online quickly and efficiently, whether in a corporate or IDC environment. Time is money, whether provisioning new data center customers, upgrading their bandwidth or leased services, or providing quick, coordinated and efficient moves, adds and changes service. Choice of media in the data center may be more critical than in other wired areas, just as equipment reliability and redundancy is more critical in a hospital operating room than in business offices. Performance, flexibility, headroom, patching and error-resistance are all variables in the same crucial design formula.

CHOOSING THE APPROPRIATE CABLING MEDIA

Choosing the appropriate cabling media can affect many aspects of data center design. An entire project or facility must be considered with respect to systems and manufacturer connectivity requirements not only for present day needs but also for future requirements. Standard distance limitations and cabling performance must be considered up front to prevent additional costs and potential service disruption. In other words, the best layout is one that allows any piece of equipment to be reached from anywhere within the data center without breaking any distance rules. The expected life of the cabling should be considered in respect to supporting multiple generations of electronic equipment and bandwidth performance improvements, with minimal requirements for pulling up floor tiles or adding media to overhead raceways.

The ANSI/TIA-942 standard recommends ANSI/TIA Category 6/ISO Class E as the bare minimum copper cable. Category 5 and Category 5e/ISO Class D are not recommended for use in data centers because neither will support 10 Gigabit Ethernet.

Over the past few years, the Institute of Electrical and Electronics Engineers (IEEE) has completed extensive work on the 10 Gigabit Ethernet standard. As 10 Gigabit Ethernet becomes more widely used, particularly in utilizing copper twisted-pair media, data centers will benefit. Structured cabling, any-to-any patch fields and high-performance copper patch cables make data center management and operations very economical and efficient. The TIA standard for Augmented Category 6 twisted-pair (including UTP) or ISO Class E_A cabling channels will provide the best investment protection for data centers since many servers, and potentially storage area networks will ultimately be connected through 10 Gigabit Ethernet local area networks (LANs) and SANs. In the area of storage networks, 10 Gigabit Ethernet presents some opportunity for creating IP-SANs utilizing the Internet Small Computer System Interface (iSCSI) protocol as an alternative or in addition to Fibre Channel. The same flexibility planners and operators gain from 10 Gigabit Ethernet copper and fiber LAN connectivity in the data center environment can be employed with SANs. When optical fiber is required or desired in the data center, ANSI/TIA-942 recommends laser optimized multimode 50-micron/ISO OM3 although the standard permits 62.5-micron/ISO OM1 products. Read more about the standards in Section 4.

DATA CENTER CABLING CONSIDERATIONS

Data center design and cabling infrastructure architecture has evolved over the years as needs and technologies change. In the past, the data center manager relied on experience as well as solutions that previously worked and did not work. Planning today's data center, however, requires a more rigorous approach due to the faster pace at which the data center is changing.

A data center cabling system may require a balance of both copper and fiber to cost effectively meet today's needs and support the high-bandwidth applications of the future. Rapidly evolving applications and technologies are drastically increasing the speed and volume of traffic on data center networks. Ensuring that a cabling solution is designed to accommodate the higher transmission rates associated with these evolving bandwidth intensive applications is critical.

The standards committees recognize the evolving needs of the industry and are reacting. ISO is currently in the process of developing cabling standards for extending the bandwidth in copper and 50-micron fiber to support the growing requirements.

> The structured cabling architecture commonly used for data centers requires a reliable high-performance, high-density design with flexible guidelines for quick installation, future readiness and easy-to-use applications.

In order to address these criteria, the following must be considered and prioritized:

- The sophistication of the network applications
- The kind of traffic expected on the various portions of the data center network based on number of users, data transfer requirements of each user, LAN architecture, etc.
- The life expectancy of the network and cabling infrastructure
- The frequency of moves, adds and changes
- The growth potential of the network over its expected life
- Any adverse physical conditions in the customer's data center
- Any access restrictions whether physical or time related

Customers are looking for high-performance solutions for a more effective overall operation of their data center network. Manageability is essential; without it, the cabling infrastructure takes over the data center in a short amount of time. To increase control over the data center infrastructure, structured cabling should be implemented. The key benefit of structured cabling is that the user regains control of the infrastructure rather than living with an unmanageable build-up of patch cords and mass of cables under the floor.

The initial data center must be designed so it can be scaled quickly and efficiently as its requirements grow. To meet the requirements and demands of the data center, the topology in the data center as well as the actual components used to implement the topology must be explored.

Several factors affect cable selection including the type of solutions used (field termination versus factory termination); conduit needs (innerduct versus interlocking armor); cable tray/conduit space availability (cable density/size requirements) and the flame rating of the installation area (NEC requirements).

CABLING INFRASTRUCTURE: COPPER VS. FIBER CABLE AND CONNECTIVITY CONSIDERATIONS

Choices between fiber, copper or the selective use of both depend on a variety of criteria including:

- Bandwidth and performance required per data center area
- Immunity to Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI)
- Need for density and space saving connectivity
- Flexibility and speed of reconfiguration
- Device media interface considerations
- Standardization
- Future vision and tolerance for recabling
- Cost of electronics.

THE CASE FOR FIBER

Fiber can provide numerous advantages over copper in a data center environment.

- Fiber systems have a greater bandwidth and error-free transmission over longer distances allowing network designers to take advantage of new data center architectures.
- Cost of fiber optic solutions is comparable with extended performance copper cabling (Category 6A/ISO Class E_A and Category 7/ISO Class F).
- Optical data center solutions are designed for simple and easy handling and installation.
- Fiber systems are easier to test.
- Optical fiber is immune to EMI/RFI.
- Faster installations (up to 75 percent faster) offer time and cost savings to data center developers, operators and contractors.
- High-density fiber optic systems maximize valuable space. Fiber's small size and weight requires less space in cable trays, raised floors and equipment racks. As a result, smaller optical networking provides better under-floor cooling and gives precious real estate back to the data center.
- Fiber has the ability to support higher data rates, taking advantage of existing applications and emerging high-speed network interfaces and protocols. Multimode fiber optics support:
    - 10 Mbps/100 Mbps/1 Gbps/10 Gbps Ethernet
    - 1/2/4 Gbps Fibre Channel
- Fiber provides "future proofing" in network infrastructure.
- Laser optimized 50-micron/ISO OM3 fiber is generally recommended by storage area network manufacturers because of its higher bandwidth capabilities.
- The next IEEE proposed Ethernet speed will be for 40 Gbps and 100 Gbps only over fiber and a short distance of 10 meters over copper.

FIBER USE IN THE DATA CENTER

Data center wide area network (WAN) connections vary, but most IDCs are typically fed with at least two redundant and diversely routed OC-48 (2.5 Gbps) fiber pairs. Some will soon have OC-192 (10 Gbps) connections and higher. Corporate data centers typically subscribe by increments of T1s (1.5 Mbps) or T3s (45 Mbps) and in some metro areas, 100 Mbps native Ethernet speeds and higher are available. Bandwidth distributed to servers and other devices may range from 1 Gbps to 10 Gbps or more depending on applications and data center models.

In CDCs, cabling infrastructure often mimics the commercial building distribution model with fiber used in the backbone (such as a vertical riser) and copper used to connect the servers (similar to horizontal distribution). While some IDCs follow this model, there is an increasing trend to take fiber as close to the devices as possible. Fiber can provide increased bandwidth with multimode supporting up to 10 Gbps Ethernet. Fiber can also provide up to 60 percent space savings over copper cabling. This can be an important factor as equipment density and heat dissipation needs increase. Space below access floors is getting crowded and can seriously restrict airflow needed for cooling. Interlocked armor jacketing can also provide additional protection if necessary and further reduce the need for underfloor raceway.

Fiber termination and patching equipment now allow up to 96 fibers to be terminated in one rack space (1U). This feature makes it attractive in some designs to terminate fiber close to server cabinets or racking rows (or even within them). While many servers now come in 1U configurations with dual Ethernet interfaces, some have started to appear with optical connections as well. This trend toward optical networking would benefit from a flexible "fiber or copper last meter" flexible patching point within a server cabinet row. This design, while providing the maximum flexibility and growth insurance, has many variations and depends entirely on the data center operator's business objectives.

Interestingly enough, the use of fiber over copper is no longer as much a cost consideration as it has been in the past. In the data center environment, most agree that 10 Gigabit Ethernet will be common, so if copper media is to be used, only the highest available grade of cabling (Category 6A/ISO Class E_A or Category 7/ISO Class F) will provide the required error free transmission, headroom and performance criteria. Today, the cost of a high-quality copper channel is economically equivalent to a fiber solution if electronics are not a factor. A fiber solution may provide other advantages such as extended distance (beyond 100 meters) and EMI/RFI protection. Installation cost also is favorable with fiber, particularly when a modularized preterminated solution is adopted, often yielding 75 percent savings over a field-terminated approach. For example, installing preterminated fiber in a large (100,000 sq. ft./10,000 sq. m+) data center can take as little as 21 days to purchase and install along with offering easy and effective moves, adds and changes as well.

Traditional vs. Preterminated Fiber Solutions

In commercial building installations, an optical fiber cabling link is typically assembled in the field at the job site. The cable is pulled in from a reel of bulk cable, cut to length, attached to the patch panel housing and terminated with field installable connectors on each end. The terminated ends are then loaded into adapters in rack or wall mountable housings. Finally, the complete link is tested for continuity and attenuation.

The most efficient optical infrastructure is one in which all components are preterminated in the factory. Connectors are installed, tested and packaged in the factory. The installer unpacks the components, pulls the preconnectorized cable assembly into place, snaps in the connectors and installs the patch cords connecting to the end equipment. This is the fastest installation method and provides the best solution for turning up servers quickly and lessening the risk of not meeting the customer's availability expectations.

The design and product selection process remains the same with selection and specification of fiber type, fiber count, cable type, connector type and hardware type appropriate for the environment.

WHY PRETERMINATED FIBER SYSTEMS?

- Up to 60 percent smaller optical networking solution freeing up raised floor and racking space
- Get online quicker with up to 75 percent faster installation
- Modular design for faster moves, adds and changes
- Defined accountability, built-in compatibility
- Factory terminations
- Consistent results from an ISO 9001 / TLQ 9000 quality architecture
- Systems are factory tested before shipment, reducing risk
- Eliminates variability in material costs

BENEFITS OF PRETERMINATED FIBER SOLUTIONS

With a little planning prior to ordering, preassembled solutions offer several advantages over the traditional installation.

- An optical fiber link can be quickly and easily installed. This is advantageous for projects where system downtime must be minimized or where disruption of the floor space cannot be tolerated. Therefore, a preassembled solution can be useful to have on hand for emergency repairs or for the re-cabling of a facility.
- A preassembled solution can be useful where cost control of a project is important. The completion of the labor assembly steps at the factory can significantly reduce the variability of installation cost in the field.
- A preassembled solution can increase the versatility and productivity of the installation crew with fewer demands on specialized tooling and installation skills.
- An optical fiber link can be completely assembled and tested prior to leaving the factory. (This does not completely remove the need for field testing after installation for link certification.)

IN SUMMARY

The labor savings associated with using factory terminated cables in most instances make it a more economical solution than field termination of fiber cables. Not only do factory-terminated cables eliminate the labor costs associated with installing connectors in the field, they also eliminate the need to spend money on redoing work that has failed as well as the cost of additional connectors. Factory terminated cable comes from the manufacturer where it was prepared under the supervision of fiber optic experts in an environmentally controlled setting with quality inspection and testing. Connectors are attached to individual strands of fiber in an automated factory process that is not as subject to human error. Once attached to the fiber cable, the connections are tested to confirm quality and performance.

50- VS. 62.5-MICRON FIBER

In terms of physical properties, the difference between these two fiber types is the diameter of the core—the light-carrying region of the fiber. In 62.5/125 fiber, the core has a diameter of 62.5 microns and the cladding diameter is 125 microns. For 50/125, the core has a diameter of 50 microns with the same cladding diameter. The diameter measurement of the fiber core has an inverse relationship to the effective bandwidth and the distance limitations of the fiber. As the core size decreases, the bandwidth and distance capabilities increase.

Bandwidth, or information-carrying capacity, is specified as a bandwidth-distance relationship with units of MHz-km (megahertz over one kilometer). The bandwidth needed to support an application depends on the data rate of transmission. As the bandwidth (MHz) goes up, the distance that bandwidth can be transmitted (km), goes down. A high-bandwidth fiber can transmit more information for longer distances.

While 62.5-micron/ISO OM1 fiber has been the most common multimode optical cable used in local area network applications, 50-micron/ISO OM3 fiber is the standard for storage area networks and their Fibre Channel data link connectivity. The 50-micron/ISO OM2/OM3 fiber was chosen because it supports longer Fibre Channel cabling distances (such as 150 m at 400 Mbps using short wave length 850 nm optics) when compared with 62.5-micron/ISO OM1. This is also true for Gigabit Ethernet (600 m) and exceeds the computer room objective of 100 meters for the 10GBASE-T standard finalized in June 2006. The increased information-carrying ability and adoption for SAN/Fibre Channel usage within data centers has changed the design recommendation to laser optimized 50-micron/ISO OM3 fiber throughout the data center. One such IDC design envisions Ethernet and Fibre Channel distribution switches sitting between server cabinet rows and SAN equipment, providing any-to-any configuration capabilities and a migration path to all optical networking within the data center.

COPPER MEDIA AND THE 21ST CENTURY DATA CENTER

Today, there are high-performance copper cabling solutions that are capable of supporting 10 Gigabit Ethernet reliably up to 100 meters. With the publication of the IEEE 802.3an standard in June 2006, the use of 100-ohm twisted-pair cabling media to support 10 Gigabit Ethernet, otherwise known as 10GBASE-T, became a reality. Up until the publication of the 802.3an standard, the only other Ethernet-based protocol specifying the use of copper cabling as its transmission medium was the IEEE 802.3ak or 10GBASE-CX4 standard. Although 10GBASE-CX4 supports 10 Gbps data transmission, its limited transmission distance of 15 meters and incompatibility with the more common RJ45 physical interconnect limited its adoption in the market. These limitations do not exist with 10GBASE-T. 10GBASE-T has the advantages of lower transceiver costs when compared to 10 Gigabit Ethernet optical modules and 100 meter reach using structured wiring systems based on the RJ45 connector. These attributes will continue the deployment of copper twisted-pair cabling for horizontal, or non-backbone, distribution between LAN switches and servers. Only the best Category 6A/ISO Class E_A or Category 7/ISO Class F media that exceed the minimum standard guidelines for data transmission with full channel performance should be considered.

It is important to keep in mind the strengths of each system and install products with characteristics that match the equipment or service demands. One such example involves using Category 6A/ISO Class E_A patch cords as a transition point between fiber-connected Ethernet switches and copper-interfaced servers within server cabinet rows or "racking neighborhoods." These high-end cables will provide ample bandwidth and more than enough insurance against dropped packets.

Note: See Section 4 for more information on copper twisted-pair solutions for data centers.

Copper or Fiber?

There are three strong reasons for the broad acceptance and rapid growth of twisted pair as the horizontal medium: low initial cost, the ability to deliver higher data rate LAN services and the flexibility to use one medium for all services. As speeds increase, copper-based LANs will require more complex and expensive electronics. Although, fiber's significant bandwidth distance gives it advantages over twisted pair in centralized architectures. However, a centralized architecture may be inappropriate or impractical to implement in many current building environments. In addition, in a traditional hierarchical star architecture, fiber loses some of its hard-fought advantages.

In the majority of situations, copper cabling remains the preferred choice for the final link to the desktop, and other short links such as those found in data centers.

Cost Considerations

The initial 10 Gigabit Ethernet standard was undertaken by the IEEE 802.3ae committee, based primarily on fiber optic technology. Although the enterprise 10 Gigabit fiber electronics are maturing and gaining acceptance, they still remain costly compared to copper. The initial cost of 10 Gigabit copper systems is projected at 40 percent of 10 Gigabit fiber products and is expected to widen over time. Hence, at shorter distances with a large number of links, 10 Gigabit copper based versions become more attractive.

Growth in 10 Gigabit Copper Solutions

10 Gigabit Ethernet technology continues to evolve and improve, causing wider adoption. Blade servers, networked enterprise switches, video servers and other applications can benefit now from 10 Gigabit speeds in storage, system backup, teleconferencing and surveillance. Technical advances have enabled the higher density, reduced power and improved cost-effectiveness needed to attract all of the major system developers. The development of 10GBASE-T by the IEEE 802.3an committee is expected to only accelerate this market acceptance.

TYPES OF COPPER CABLE CONSTRUCTION

One step that can help protect a data center in case of a fire is to look at cable construction. Cable is one of the largest fire fuel sources in the data center. The three types of typical communication cable construction are general-use CM, CMR riser and CMP plenum cables. These are combustible because they will eventually burn. A fourth cable type is called limited combustible cable or LCC, and its performance in laboratory tests is considered to be outstanding. Both the jacket and the insulation are made of 100 percent FEP or Teflon® compounds. CMP plenum cable gets a significantly better rating than CMR riser or CM largely because of the flame retardant jacket over the primary conductor insulation of Teflon. See the sidebar to learn about some compelling reasons why data center operators consider using Limited Combustible Cable to protect people and equipment.

Currently, the use of LCC is voluntary. It is neither required nor prohibited based on its superior fire and smoke limiting characteristics. However, the National Fire Prevention Association (NFPA), which publishes the National Electrical Code (NEC), is considering it for inclusion in a future code revision.

Many companies are starting to use LCC. Insurance companies are studying test results to determine if there should be financial incentives to stimulate adoption. The clear benefit in data center environments is the superior smoke particle deterrence.

Low-Smoke Halogen-Free (LSZH) cables are specified in many countries across Europe. Although these cables burn, they do not give off any toxic fumes and only limited smoke. These cable types meet various specifications across Europe covered by the IEC standards group.

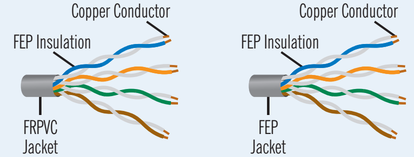
LIMITED COMBUSTIBLE CABLE IN ACTION

In tests conducted at the DuPont labs in England, four cable types were subjected to a 1-megawatt flame in a simulated plenum space. CMR combustion and noxious smoke was prevalent within two-and-a-half minutes of being exposed to the flame. Within nine minutes, the fire spread downstream and became a full-fledged cable fire half a minute later. The same pair count cable in a CMP construction, a plenum rated cable with FEP jacket, caught fire within two-and-a-half minutes but with much lower smoke production. The fire spread downstream in seven to ten minutes and continued burning at a fairly constant rate as opposed to the rapid incineration of the PE/FRPVC insulated riser cable.

Cable Type	Insulation	Jacket
LCC (Plenum)	**FEP**	**FEP**
CMP (Plenum)	**FEP**	**FRPVC***
CMR (Riser)	**PE**	**FRPVC***
CM (General Purpose Communications)	**PE**	**FRPVC***

* Different Compounds

The limited combustible cable provided an altogether different picture with no appreciable smoke or fire either at the point of exposure to the flame or downstream after enduring the same conditions for more than 25 minutes.



Standard "Combustible" CMP Cable **Limited Combustible Cable**

POWER CABLES AND ACCESSORIES

Power cables are the lifeline of any data center. The selection of power cables that meet all requirements for performance, reliability and safety—and which provide these characteristics at a reasonable cost—involves a number of important considerations.

One of the first and most important considerations is to determine how much total electrical power will be needed. Data centers typically require 35 to 250 watts per square foot of floor space depending on equipment densities, data processing speeds, power reliability (uptime) requirements and possible future equipment upgrades. One method of determining power requirements as a function of reliability is to classify the facility into Tiers (I through IV) using the guidelines given in Annex G.5 of ANSI/TIA-942.

Total data center power requirements are also sometimes calculated from the number of rack locations and the average power consumed by each rack. This is often done on a row-by-row basis to improve accuracy. The specific type of electrical load (circuit voltage and current, AC or DC, single- or three-phase, etc.) and the location of each within the facility must also be determined. Adequate electrical power for heating, ventilating, air conditioning, lighting and other utilities must be carefully planned as well.

Distribution of electrical power throughout a data center facility is accomplished with a large array of components. Required, for example, are transformers, switchgear, service-entrance panels, breakers, distribution panels, emergency backup generators, automatic transfer switches, batteries, control panels, wire and cable, junction boxes, plugs, receptacles, etc.

	Tier I: Basic	**Tier II:** Redundant Components	**Tier III:** Concurrently Maintainable	**Tier IV:** Fault Tolerant
Number of Delivery Paths	Only 1	Only 1	1 Active, 1 Passive	2 Active
Redundant Components	N	N+1	N+1	2 (N+1)
Support Space to Raised Floor Ratio	20%	30%	80-90%	100%
Initial Watts/ft	20-30	40-50	40-60	50-80
Ultimate Watts/ft	20-30	40-50	100-150	150+

The power requirements for the data center should be dictated by the Tiering level that a customer wishes to achieve. The Uptime Tiers are covered in ANSI/TIA-942 standard as well as in Anixter's Standards Reference Guide in greater detail.

Raceways and/or cable trays are also required for protection and support of the installed wire and cable. The choice of raceway versus cable tray primarily depends on National Electrical Code requirements, technical requirements and cost. There are over a dozen raceway types from which to choose including metallic and nonmetallic versions of rigid conduit, electrical metallic tubing (EMT), electrical nonmetallic tubing (ENT), wireway, surface raceway, flexible metal conduit and liquid tight flexible conduit. Cable tray types include those made of steel or aluminum and encompass a large variety of strengths, widths, depths, rung spacing and lengths. The requirements and permitted uses for the various raceway types as well as cable tray are covered in articles 300 to 400 of the NEC. In Europe, the CENELEC EN50174 standards should be referenced.

For data centers located in the U.S., power cables and their installation must usually comply with the NEC as well as any applicable state or local codes. Although the NEC does not officially apply to "installations of communications equipment under the exclusive control of communications utilities," virtually all utilities choose to comply to reduce their potential liability as well as their insurance premiums. For Canadian installations, the Canadian Electrical Code (CSA C22.1) applies rather than the NEC (NFPA 70). The codes of both countries require the use of specific UL Listed or CSA Certified cables in each application. For example, cables installed in cable trays must meet certain fire test requirements to minimize fire propagation in the event of a fire. One power cable type frequently used in tray in U.S. data centers is NEC type RHH (per UL 44) with a "For CT Use" rating. This optional rating is based primarily on fire test performance and is one of many specific ratings that permit a cable to be installed in tray. Other optional ratings include ST1 (limited smoke) and LS (low smoke) ratings that verify a cable meets specific smoke emission requirements in UL 44. These ratings are not required by code. Data center power cables are also sometimes known as "KS spec" cables, which is a reference to central office power cable standards that have been in use for roughly half a century. KS power cable specifications are owned by Tyco Electronics Power Systems and include cable standards such as KS-24194™ and KS-22641.™ Other power cable and power cable installation standards often applicable to data centers include NEMA WC 70 (ICEA S-95-658), Telcordia GR-347-CORE, Telcordia GR-1275-CORE, ANSI/TIA-942 and ANSI-J-STD-607-A-2002. The TIA standard includes information on the selection, design and placement of power and grounding systems within a data center. The ANSI standard covers the design of the grounding and bonding infrastructure.

In Europe, power cables and their installation must comply with the European electrical codes as well as any applicable local codes. The electrical codes of some countries require the use of specific cables in each application. For example, cables installed in cable trays must meet certain fire test requirements to minimize fire propagation. Another frequently specified rating, the "low smoke" rating, is not required by code but verifies the cable meets the European standards for smoke emission requirements.

Other cable types are permitted in other locations within a data center. For example, NEC Article 645 on Information Technology Equipment spells out in detail the types of cables permitted under the raised floor of a computer room including NEC power cable types such as TC (tray cable), MC (metal clad), AC (armor clad), NPLF (non-power-limited fire alarm cable) and type DP (data processing cable). If installed in conduit, additional cable types can also be used.

In addition to making sure all power cables meet applicable codes and standards, many engineering decisions are necessary concerning cable characteristics. These include characteristics such as conductor size, voltage rating, cable flexibility (ASTM Class B or Class I stranding), with or without cotton braid, insulation color RoHS (Restriction of Hazardous Substances) compliance, etc.

Conductor size is primarily based on ampacity, voltage drop and energy efficiency considerations, while grounding conductor size depends on the rating of the overcurrent device protecting the circuit. Minimum grounding conductor sizes are given in Table 250.122 of the NEC.

Power cable accessories also need to be carefully considered. This includes decisions on whether to install the cable in conduit or tray, size of the conduit or tray, strength of supports, method of securing the cable (lace, nylon cable ties or other), grounding conductor bonding methods and maximum tray or conduit fill permitted by code. The method of securing the cable is especially important for DC circuits because of the potential for significant cable movement resulting from the magnetic forces created by high fault currents.

Cable accessories such as lugs, barrel connectors, taps, fittings (also referred to as glands or connectors), etc. must be selected and coordinated with the power cable in mind to prevent last-minute sizing problems. For example, two different types of conductor stranding are generally used in data centers: ASTM Class B "standard" stranding and Class I "flexible" stranding. Class I stranding is generally used for battery cables, cables that must be flexed in service or cables that are installed in unusually small spaces. Class I stranding has more (but smaller) individual wires in a given conductor gauge (AWG) size than does Class B stranding. Because of the additional space between wires in a Class I strand, conductors with Class I stranding have a larger diameter. To accommodate the larger diameter, lugs and connectors with larger inside diameters (before crimping) must be specified. These are commonly known as "flexible" lugs. Within Europe, two different types of conductor strandings are generally used in data centers: EN 60228 Class 2 "standard" stranding and Class 5 "flexible" stranding. Class 5 stranding is generally used for battery cables, cables that must be flexed in service or cables that are installed in unusually small spaces. Class 5 stranding has more (but smaller) individual wires than does Class 2 stranding. Because of the additional space between wires in a Class 5 strand, conductors with Class 5 stranding have a larger diameter. To accommodate the larger diameter, the lugs and connectors must have larger inside diameters (before crimping) than standard lugs. To confirm trouble-free service over the life of the installation, lugs and connectors should always be applied with the proper crimping tool, correct die and adequate preparation of the cable prior to crimping.

ELECTRICAL POWER SYSTEM CONSIDERATIONS

An on-time, trouble-free, start-up of a data center facility requires detailed preplanning of the entire electrical power system. Careful integration of the primary electrical system with UPS, battery and other backup systems is essential. Because of the large number of interrelated factors involved, the detailed design of the entire electrical power supply system—including cables, cable accessories and all other components of the system—is usually best completed by a professional electrical design group experienced in data center electrical power supply systems.

Energy Efficiency and Environmental Considerations

High-voltage DC power

- 20 - 40% more efficient than A/C conversion*
- Reduces fossil fuel consumption

Cable plant media and design

- Increases air flow
- Improves cooling efficiency

Equipment layout

- Promotes thermal management and cooling efficiency

Deployment

- Reduces waste at the job site
- Improves construction efficiency

Monitoring / Management

- Environmental
  – Improves operational efficiencies
- Infrastructure
  – Asset utilization, business resiliency, security

Alternative Power

- Solar
- Wind
- Fuel cells

* Source: Lawrence Livermore Lab

INTELLIGENT INFRASTRUCTURE MANAGEMENT (IIM) WITHIN A DATA CENTER ENVIRONMENT

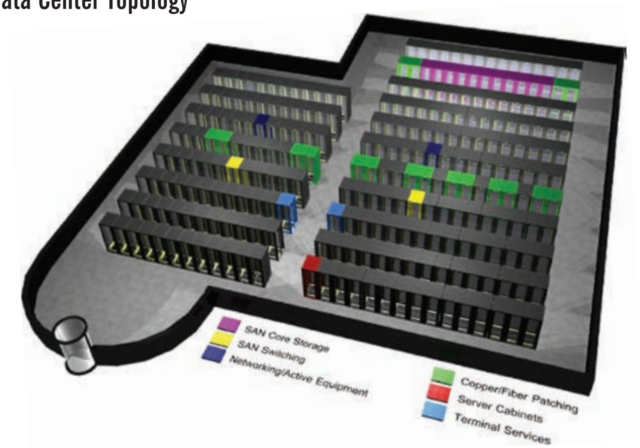
Organizations are increasingly dependent on their IT networks to provide a competitive advantage as well as meet both customer and shareholder needs. These networks are becoming increasingly complex and are required to support a rapidly increasing number of applications coupled with ever increasing levels of IT service availability. The migration toward the goal of "on demand," high availability, converged enterprise networks is set to provide a considerable challenge to those organizations wishing to reap the undoubted business benefits. It will require significant system downtime reductions to achieve this goal and it is extremely unlikely that improvements of this magnitude can be delivered by the manual infrastructure management systems and processes in use today.

The realization that the 100 percent availability of IT services will assume ever-greater significance has led to the introduction of IT service management. Setting the benchmark for "best practice" in service management is ITIL (IT Infrastructure Library), which has been adopted as the de facto global standard for IT service management.

At the core of an IT service management framework are the configuration, change and incident management (e.g., restoration of host name and location) processes. The accuracy and quality of the information contained within the main Configuration Management Database (CMDB) is fundamental in ensuring the effectiveness, efficiency and quality of all associated IT service management processes. Similarly, the management of changes to this information is also critical as service delivery managers must know the exact implications of carrying out any changes before they take place. Avoiding the potential for a "butterfly effect" to develop as a result of a poorly executed change or problem resolution is essential if 100 percent service availability is to be maintained.

Creating such systems and processes based upon a traditionally managed cabling infrastructure is an arduous task as the connectivity and asset information contained within traditional tools and documentation processes, being manually maintained, is inevitably inaccurate, outdated and therefore cannot be safely incorporated into an accurate CMDB. This creates a large degree of uncertainty concerning the physical location and associated connectivity of network devices, services and service paths or routes. This severely limits the speed of application deployment and the quality of IT service delivery.

Sample Data Center Topology



By adopting the correct "intelligent" sensor technology and infrastructure management software tools as a key part of their cabling strategy, data center managers can create a platform capable of addressing these problems, providing a 100 percent accurate, real-time trusted source of connectivity and asset information that can be incorporated within the core CMDB and consequently, utilized to enhance all associated IT service management tools and processes. Any physical additions or changes to the network configuration are quickly and accurately planned and executed before being automatically updated and reflected across all management processes, thereby optimizing process efficiency and aiding communication between work streams and coordinating events. Unauthorized events/incidents affecting the infrastructure can be instantaneously identified and forwarded to the appropriate service management tool or team for rectification.

Not surprisingly, these process efficiencies and workstream productivity improvements can result in significant reductions in operational expenditure. In traditionally managed data centers, the addition of a new application server to a complex infrastructure requires a considerable amount of intricate planning before it can be safely commissioned. Sufficient space has to be found within a cabinet, along with the appropriate power and environmental controls. Perhaps the most complex and time consuming task (and one that can be highly prone to error) is the planning of the multitude of cable routes required to run from the LAN, SAN and terminal services fabric (see Sample Data Center Topology at left) to the server cabinet and consequently, the target server and its associated Network Interface Cards (NICs). While management tools exist to automate the space, power and environmental planning process, prior to the introduction of Intelligent Infrastructure Management, the planning of service routing was a long and complex manual process.

THE IMPACT OF INTELLIGENT INFRASTRUCTURE MANAGEMENT ON DATA CENTER OPERATIONS

- Reduced cost and increased effectiveness of IT operations
- Saves time and manpower required for planning and implementing change, performing audits and responding to faults
- Optimization and automation of the change control process along with the elimination of configuration errors
- Reduced truck rolls equals reduced costs, particularly for "lights out" environments
- Real-time location and tracking of all network assets can drastically improve effectiveness of existing asset management tools
- Provides audit trails and reporting capabilities (for Sarbanes Oxley)
- More effective use of network resources—confirms optimum switch port utilization thereby avoiding unnecessary purchases
- Key personnel's core skills can be extended across the entire enterprise network, ensuring a reduced need for local familiarity
- Governance of sub-contractors and outsourcing service providers—confirms SLAs (Service Level Agreements) and billing are actively monitored and controlled

Leading Intelligent Infrastructure Management solutions provide an auto-service, provisioning capability within their work order management functionality that automatically routes the required services to the necessary location via the most efficient and effective cable links. The work orders required to execute the activity are automatically created, issued to the appropriate technician and managed by the Intelligent Infrastructure Management system. Any actions that do not adhere 100 percent to the work order are instantaneously identified and rectified if required.

Utilizing Intelligent Infrastructure Management solutions to automatically provision services within the data center environment has been proven to reduce server commissioning time by up to 80 percent, while simultaneously reducing the number of incidents caused by poorly executed change. If incidents occur, Intelligent Infrastructure Management solutions can dramatically reduce mean time to resolution (MTTR) by up to 40 percent.

The optimization of IT service management processes and the resulting improvements in work stream productivity and efficiency so that data center operators will attain the goals of continuous service delivery while maximizing the return on their IT investments and achieving enhanced customer satisfaction.

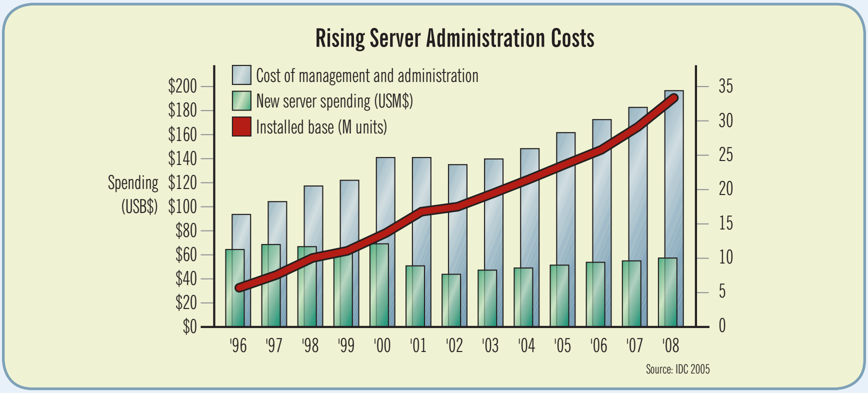
KEYBOARD, VIDEO, MOUSE (KVM) SWITCHES

Data centers are expanding to keep up with the increasing amount of data in today's rapidly growing information infrastructure. This proliferation calls for cost-effective solutions that can provide centralized control of IT devices in the data center.

As file, e-mail, Web and application servers began to increase on corporate LANs, their management became more complex. (See Rising Server Administration Costs graph at right.) While servers typically do not have their own KVM consoles, they still need to be configured, maintained, updated and occasionally rebooted. KVM switch is short for keyboard, video and mouse. Traditional KVM switches connect directly to the servers and require operators to have physical access to the console. In this way, a single KVM switch can be used to access and control an entire room or rack full of servers.

IP-based KVM switches allow administrators to expand their reach over distributed systems, improve security and reduce costs and downtime. With a KVM over IP switch installed at the data center, IT operators can sit at a single workstation anywhere in the world and have secure access and control of many servers in multiple locations across the globe. For this reason, server management with KVM over IP switches is becoming the cornerstone of most data centers today.

KVM over IP technology delivers data centers with unsurpassed scalability and flexibility by providing centralization and standardization. Unlike traditional KVM switches, KVM over IP switches can transmit KVM information over standard TCP/IP connections. This approach leverages a company's existing network infrastructure by enabling operators to control servers and other distributed IT assets remotely over local area networks and wide area networks using a single computer located anywhere in the world.



KVM solutions provide centralized control, scalability, remote access, security and flexibility as well as the following benefits:

- Reduced costs, space and energy savings—KVM switches provide immediate paybacks in hardware savings, free up valuable physical space and reduce demands on electric power and cooling systems.
- Improved business continuity—KVM switch solutions allow "out-of-band" access to a company's servers and other IT devices. As such, they allow IT personnel to access, control and manage the company's servers and/or serial devices even if the corporate network itself is down.
- Improved security via "lights out" operations—Advances in KVM technology allow users to be further and further away from connected devices.
- Improved staff productivity—The virtual reach provided by IP solutions has an additional benefit; all of a company's IT experts can now manage servers or respond to incidents from wherever they are, across the hall, at home or across a multi-site network. These "virtually" centralized human resources can eliminate costly travel time.
- Accelerated incident response—Enterprise-wide, Web-accessible solutions can dramatically shorten incident response times since administrators can take action from anywhere.
- Increased hardware platform and operating system independence—KVM switches work in heterogeneous server environments.

With so many variables to consider when building a data center, today's IT and business leaders are cutting new trails through uncharted territory. The next few years will unveil the developments, risks and rewards of the new economy as entrepreneurial innovation and the digital age take root, powered by business technology, the Internet and brought to you through 21st century data centers around the world. Selecting the right infrastructure for your data center will be key to maintaining uptime 24/7, year round.

Factors You Should Consider When Building a Data Center

- Professional engineering
- Power requirements and cabling
- Adequate cooling
- Efficient allocation of space
- Proper racking, enclosures, pathways and access flooring
- Redundancy and path diversity
- Security
- Storage
- Flexible and adequate connectivity
- Copper or fiber cabling and management
- KVM switches
- Intelligent Infrastructure Management solutions

When it comes to the communications infrastructure, Anixter can make several specific recommendations. While the ANSI/TIA-942 standard for data centers specifies a copper minimum of Category 6/ISO Class E cabling, Anixter recommends cabling to support 10 Gigabit Ethernet in new data centers and during data center expansion. At minimum, a Category 6A/ISO Class E_A "augmented" construction is needed to provide bandwidth in the 500 MHz range with proven control of alien crosstalk.

Anixter continues to recommend fiber in all backbones including the data center. Laser-optimized, 50-micron/ISO OM3 is the fiber of choice—again to confirm the data center is ready whenever and wherever 10 Gigabit Ethernet becomes a requirement. Additionally, limited combustible cable has strong merit in limiting loss—both of life and property—and may be a requirement when the NEC is updated in the future.

It pays to use the latest security and monitoring technology to protect assets and uptime from internal and external threats. Video surveillance, access control and environmental monitoring are all areas where Anixter can provide its product expertise during the data center design and upgrade process.

Anixter understands the challenges facing today's data center professionals and embraces standards such as ANSI/TIA-942, which provides a comprehensive roadmap for success. Anixter supports data center customers in achieving their goals of availability, reliability and operational efficiency.

SECTION 4

Best Practices for Data Centers: Data Center Standards and Associations

ANSI/TIA-942: DATA CENTER STANDARDS

Data Center Growth Drives Need for Standards

Over the past several years, more and more businesses have moved to the Web. Corporations continue to recentralize their computing platforms after years of decentralization. The effects of globalization require around the clock access to systems, data and applications. Disaster recovery and business continuity requirements demand redundancy and other fail-safe methods to confirm financial stability. Mergers and acquisitions continue to stretch IT departments with systems integration challenges. These trends are driving a renewal in new data center construction and upgrades to existing facilities.

Typically, the task of planning a new data center or updating an existing one falls on the IT department. They will first identify needs and then research and sort through a myriad of approaches to complex design and construction requirements. Recently, data center projects were either the domain of consultants and engineering firms that specialized in business-critical environments or left to IT departments to struggle with on their own. To avoid "re-inventing the wheel," many sought the guidance of peers in other corporations or reached out to other members of the data center community who had gained experience through their own data center projects.

To address this growing need for information, the Telecommunications Industry Association (TIA), formed a workgroup to study the problem and develop a standard. The result of several years of work was ANSI/TIA-942, which was finalized in June of 2005. This standard has both familiar and unique aspects to it. It borrows from the well-established TIA cabling infrastructure standards. However, ANSI/TIA-942 is unique because it was developed not only by standards body members but also by a cross section of the IT community including engineers, manufacturers, architects and end-users. Similar to the educational movement that resulted in commercial building wiring standards and cabling performance over the last decade, the data center now moves away from proprietary cabling systems and benefits from some common infrastructure standards.

The resulting ANSI/TIA-942 Telecommunications Infrastructure Standard for Data Centers is a 142-page, copyrighted document available for purchase through Global Engineering Documents at 1-800-854-7179 or www.global.ihs.com. It contains information specific to data centers. The following is an abridged description of some key elements described by the standard and should not be used as a replacement or substitute for the actual document itself.

Goals of the ANSI/TIA-942

The TIA defines the data center as "a building or part of a building dedicated to housing computers and support facilities." The purpose of the ANSI/TIA-942 standard is to provide a comprehensive understanding of data center design so that the designers can plan the facility, the network and the cabling system.

The goal is to provide a tool to get planners thinking about the components of data center design much earlier in the budgeting and development process. This will help gather requirements from all concerned parties—facilities, real estate, IT and corporate business units. Up to now, there has been no single standard to pull all of this together. ANSI/TIA-942 achieves its goal by going beyond the telecommunications infrastructure to include electrical, architectural, mechanical and security guidelines as well. It began with the ANSI/TIA-568 cabling model and morphed to encompass facility and space requirements. In fact, over half of the data center standard addresses facility needs.

ANSI/TIA-942 Design Elements

ANSI/TIA-942 cabling design elements provide recommendations for the grade of cable to be used in data centers relative to performance and distance requirements. Network design considers support of legacy systems while facilitating future migration to newer technologies and higher speeds. Facility design encompasses architectural, mechanical and telecom needs.

The standard speaks in terms of "shalls" or "normatives," which denote mandatory requirements, and "shoulds" or "informatives," which are more about "best practices" than hard and fast requirements. Many of these best practices are documented in nine addendums called "annexes," which are found directly following the main text. The standard includes charts and tables on topology layouts, redundancy planning and more.

Much of the ANSI/TIA-942 guidance for spaces and pathways is derived from the existing ANSI/TIA-569-B standard, which covers ducts, trays, access floors, false ceilings and conduits in horizontal and backbone paths as well as spaces in equipment and telecom rooms, entrance facilities and workstations. Rack and cabinet considerations are also addressed in considerable detail.

For more detailed information on networking standards, order Anixter's Standards Reference Guide at anixter.com/literature (North American or European version).

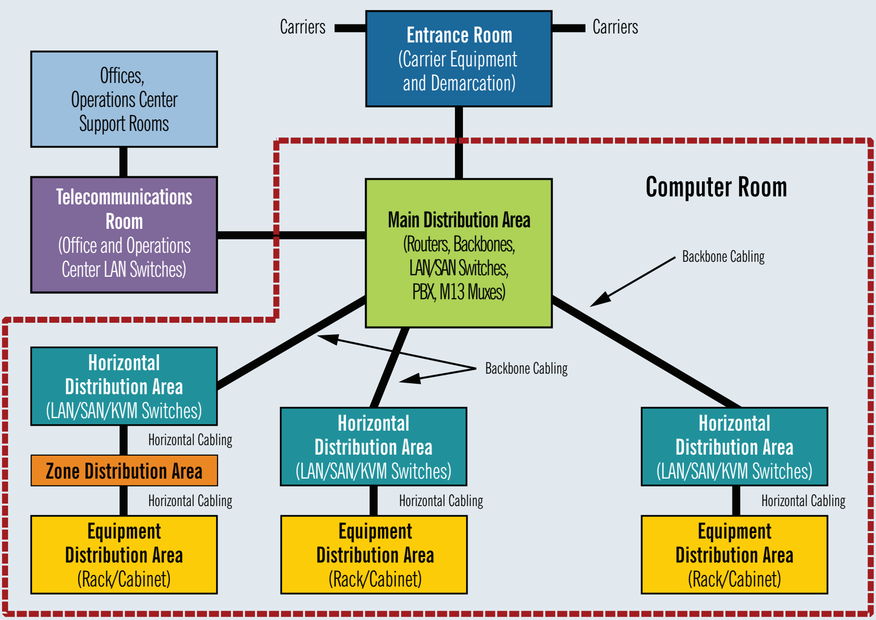
DATA CENTER CABLING TOPOLOGY

The ANSI/TIA-942 standard provides detailed guidelines for the five key spaces shown in data center topology:

- Entrance Room (ER)
- Main Distribution Area (MDA)
- Horizontal Distribution Area (HDA)
- Equipment Distribution Area (EDA)
- Zone Distribution Area (ZDA)

Other areas discussed are support rooms for heating, ventilation and air conditioning (HVAC), uninterruptible power systems (UPS), back up batteries, office space and the network operations center (NOC).

ANSI/TIA-942 Data Center Topology



Source: ANSI/TIA-942 Standard

ENTRANCE ROOM (ER)

The Entrance Room houses the interfaces between inter-building cabling and the data center structured cabling system. ANSI/TIA-942's ER section covers requirements for telecom carrier and service provider equipment and their demarcation points—where data center operator responsibility begins. The standard also covers designs for multiple equipment rooms, should that be a requirement. Guidelines for both indoor and outdoor scenarios provide recommendations based on standardized distance and splicing specifications.

Cabling choices routinely used in equipment rooms include fiber and mini coax for T-1 and T-3 digital circuits. Density and distances are specified for each of these media including copper twisted-pair cabling.

MAIN DISTRIBUTION AREA (MDA)

The Main Distribution Area is the central point of distribution for the structured cabling system. The MDA typically houses the core routers and switches for the local area network, wide area network, storage area network and the private branch exchange (PBX) telephone system.

HORIZONTAL DISTRIBUTION AREA (HDA)

Data centers contain at least one Horizontal Distribution Area. This area supports cabling to the equipment areas where the actual computing devices are found. There may be several HDAs within a data center and other floors throughout a facility may have their own HDA(s).

EQUIPMENT DISTRIBUTION AREA (EDA)

The Equipment Distribution Area houses floor-standing computing equipment as well as rack and cabinet mounted devices such as servers and other communications hardware.

ZONE DISTRIBUTION AREA (ZDA)

To accommodate cabling interconnection and termination in overhead spaces or under floors, one Zone Distribution Area may be included within a horizontal cable run. Connectivity density in zone apparatus enclosures is limited and no active gear may be included.

Not all of these five defined spaces must be used, but all options for accommodating future growth should be considered when planning facilities.

Detailed guidelines are also provided within the ANSI/TIA-942 standard to address racking, connectivity, power and other considerations for each of the areas described. Additional "best practices" are contained in the informative annexes.

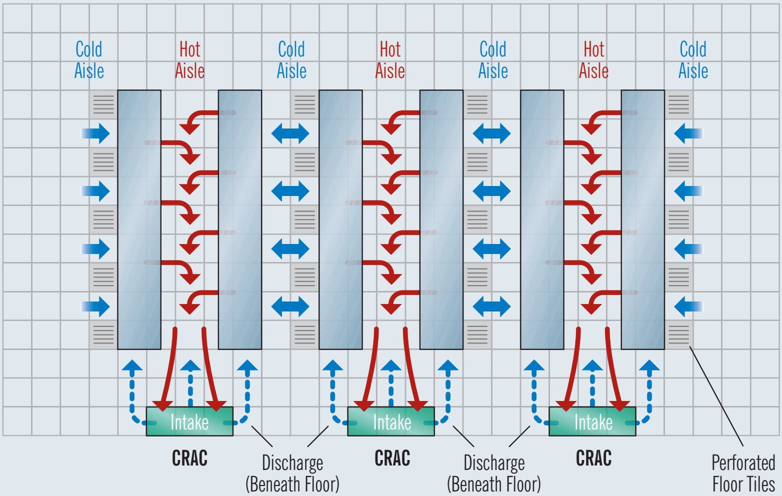
HOT AND COLD EQUIPMENT AISLES

As mentioned in Section 2, cooling and heat dissipation techniques are extremely important topics when it comes to designing and operating a data center. The topology section of ANSI/TIA-942 spends a fair amount of time describing proven methods for planning airflow within the data center. The hot aisle/cold aisle approach to thermal dynamics is a popular design method addressed in detail in the standard.

This method faces cabinet fronts at each other across "cold aisles" allowing cool air at the front of each cabinet to flow through and over computing equipment. Accumulated hot air from equipment is exhausted through the rear of the cabinet into a designated "hot aisle." See diagram below.

This approach creates a convection current by design that keeps cold air from mixing with hot air, which has been proven to undermine overall cooling effectiveness. This design also contributes to the efficiency of Computer Room Air Conditioning (CRAC) units by funneling only the hottest air into these units for treatment. The hot aisle/cold aisle approach greatly improves the data center's ability to maintain a controlled temperature and humidity environment. ANSI/TIA-942 also provides guidelines for placement of underfloor cabling and any other infrastructure components that might restrict airflow. An example is the recommendation for running power cables in trays below the cool aisles and low voltage communication cables in pathways below the hot aisles and, in each case, parallel with the direction of air flow.

Upfront planning for cabinet placement is also addressed with recommendations for cabinet alignment to be congruent with the edges of raised floor tiles, facilitating easy access and maintenance. The standard calls for aisles with a minimum of 3 ft. (0.91 m) of front access but 4 ft. (1.22 m) are recommended. A minimum space of 2 ft. (0.61 m) at the rear should be maintained with 3 ft. (0.91 m) suggested. If floor tiles are to be cut for additional airflow, ANSI/TIA-942 has a recommended approach designed to protect cabling infrastructure components and improve equipment access while at the same time maximizing cooling effects.



Source: HP Technology Brief, Second Edition

DATA CENTER INFRASTRUCTURE TIERS

Data center reliability and resilience are often referred to as uptime and is rated by "tiers." Data center tier ratings come from the Uptime Institute—a data center knowledge community that has published scientific guidelines for defining uptime expectations and planning guidelines for achieving performance and availability levels.

As you might expect, higher reliability relates directly to higher construction costs. Sometimes, the desired availability level becomes unrealistic, once the financial commitment is fully realized. At the very least, the Uptime Institute's tier specifications turn out to be a tremendous value to planners as they have become a uniform method for evaluating specifications, determining initial budget estimates and communicating requirements to architects and engineers. In addition to general information, the ANSI/TIA-942 informative "Annex G" contains several approaches to data center tiers in the following areas:

- Redundancy
- Telecommunications
- Architectural and structural
- Electrical
- Mechanical

Each of these tier tables contains subsystem recommendations as well. For instance, security considerations comprise four of 17 separate categories within the architectural tier specifications and each defines what is considered Tier I, II, III or IV compliant. Planners and tradesmen can therefore communicate with each other utilizing the same set of definitions and specifications for each area of the data center. The data center reliability tiers are the most common expression of how business-critical and how fault-tolerant a data center can become.

The chart below from an Uptime Institute white paper shows the tiers side by side and compares numerous features and benefits. The price to availability ratios are stark with the most dramatic jump from Tier II to Tier III. While this yields the most dramatic gain, it also commands a 50 percent price premium. Accordingly, there are very few Tier IV data centers today because usually they are just too expensive to justify. (See Uptime Institute Tiers sidebar on the following page for more information.)

Tier Similarities and Differences for Data Center Design Variables

	Tier I: Basic	Tier II: Redundant Components	Tier III: Concurrently Maintainable	Tier IV: Fault Tolerant
Number of delivery paths	Only 1	Only 1	1 active 1 passive	2 active
Redundant components	N	N+1	N+1	2 (N+1) S+S
Support space to raised floor ratio	20%	30%	80-90%	100%
Initial watts/ft	20-30	40-50	40-60	50-80
Ultimate watts/ft	20-30	40-50	100-150	150+
Raised floor height	12"	18"	30-36"	30-36"
Floor loading pounds/ft	85	100	150	150+
Utility voltage	208,480	208,480	12-15kV	12-15kV
Months to implement	3	3 to 6	15 to 20	15 to 20
Year first deployed	1965	1970	1985	1995
Construction $/ft raised floor	$450	$600	$900	$1,100+
Annual IT downtime due to site	28.8 hrs	22.0 hrs	1.6 hrs	0.4 hrs
Site availability	99.671%	99.749%	99.982%	99.995%

Source: Uptime Institute

UPTIME INSTITUTE TIERS

Tier I (Basic) (N*):
Need single path for power and cooling distribution, no redundant components, 99.671 percent availability. Susceptible to disruptions from both planned and unplanned activity. UPS or generator is a single-module system with many single points of failure. To perform annual preventive maintenance and repair work, the infrastructure must be completely shut down.

Tier II (Redundant Components) (N+1):
"Need plus one" single path for power and cooling distribution, redundant components, slightly less susceptible to disruptions—99.749 percent availability. Maintenance of the critical power path and other parts of the site infrastructure require a processing shutdown.

Tier III (Concurrently Maintainable) (N+1):
Multiple power and cooling distribution paths, but only one path active. Allows for any planned site infrastructure activity without disrupting the computer hardware operations. Contains redundant components that are concurrently maintainable with 99.982 percent availability. Tier III sites are often designed to be upgraded to Tier IV sites when cost allows.

Tier IV (Fault Tolerant) 2(N+1):
S+S* multiple active power and cooling distribution paths, redundant components, 99.995 percent availability. The site infrastructure is able to sustain at least one worst-case unplanned failure or event with no critical load impact. S+S=System+System—two separate UPS systems in which each system has N+1 redundancy. This requires all computer hardware to have dual power inputs. It supports high availability IT concepts that employ CPU clustering, RAID and DASD storage methods, and redundant communications to achieve high reliability, availability and serviceability.

* Please note: the Uptime Institute defines "N" as "Need" and "S" as "System."

Cabling Choices in the Data Center

The TIA is a North American standards body that often works in tandem with the IEEE as new networking standards are being explored. The International Organization for Standardization (ISO) is also expecting to develop new cabling standards. The use of 10 Gigabit Ethernet will see implementation in data centers where high bandwidth between server farms and storage devices is needed. Existing high-performance connectivity solutions in the data center such as Infiniband and Fibre Channel may be displaced by or augmented with Ethernet. The 10 Gigabit Ethernet standards have been developed by IEEE, ISO and TIA to address the need for manageable, standardized connectivity solutions in data centers and ultimately in commercial business environments. IEEE has defined four twisted-pair cabling system models for 10 Gigabit Ethernet data links. The first model utilizes fully screened and shielded cable—ISO Class F cable (Category 7) to achieve 100 m distances at up to 600 MHz. Much like Class F cabling, Models 2 and 3 will also support 100-meter reach. The main difference is that models 2 and 3 use twisted-pair cabling media, the TIA Augmented Category 6 and ISO Class E_A, respectively. Model 4 utilizes ISO Class E cable (TIA Category 6), which operates at 250 MHz and may achieve up to 55 m depending on the grade of the cable channel, installation technique and environmental conditions. The standards organizations realize there is often an installed base investment within existing facilities. They frequently attempt to protect a customer's investment with backward compatibility. Model 4 attempts to mitigate performance issues that may arise when utilizing Category 6/ISO Class E infrastructure to support 10 Gigabit Ethernet.

Alien crosstalk (ANEXT and AFEXT) presents a significant challenge to cable manufacturers designing for 10 Gigabit speeds. Alien crosstalk occurs through the electromagnetic signal coupling of pairs in adjacent four-pair cables. Today's innovative cable construction has shown that ANEXT can be minimized up to 100 m distances at frequencies as high as 500 MHz. This accomplishment allows data centers and other high-speed infrastructures to deploy 10 Gigabit copper data paths utilizing less expensive and easy-to-use twisted pair, in addition to fiber links.

In the cabling standards world of TIA, two projects complement the work of the IEEE. The ANSI/TIA-TSB-155 project has defined the channel and link specifications for 10 Gigabit Ethernet over the current TIA Category 6 standard. Most standards bodies will always do what they can to prevent product obsolescence within the installed base of commercial customers. This is taken very seriously because of the higher cost of replacing material within walls, between floors and between buildings. Testing procedures for measurement of the alien crosstalk effects between all pairs in adjacent cables (power sum alien near end crosstalk or PSANEXT) is outlined in this Technical Service Bulletin (TSB-155). The goal of the TSB-155 is to protect customer investment in an installed Category 6 cabling infrastructure. Additionally, TIA has considered and recommends mitigation procedures for reducing the level of alien crosstalk Category cables if it is found at significant levels in field testing.

The other committee, ANSI/TIA-568-B.2-Ad10, created an addendum to the ANSI/TIA-568-B.2 standard to develop what is referred to as "Augmented Category 6." Augmented means that standard Category 6 performance was "pushed" beyond its initial 250 MHz range to 500 MHz. This specification is commonly referred to as 10GBASE-T (10 Gigabit Baseband over Twisted Pair).

The ISO specification for 10 Gigabit Ethernet over 100-ohm twisted-pair copper (Class E_A) is currently more stringent than the current draft of the TIA Augmented Category 6 specification. In the Infrastructure Solutions Lab, Anixter verifies that all of its supported 10GBASE-T cabling products are compliant with the latest ISO draft standards. This approach offers Anixter customers more versatility and a higher performance threshold for their networks. Additionally, ensuring extra "headroom" in data networks is a product and design philosophy that Anixter has always recommended. Testing all cabling channel products to the higher standard confirms all the necessary characteristics for data center infrastructure: quality, reliability, availability and performance. Within the International standards organizations, a technical equivalent to TSB-155 has been developed under the reference IEC24750.

Another 10 Gigabit Ethernet copper media option in data centers is called 10GBASE-CX4. This option is designed to be used within a rack or cabinet to support server clusters. Beyond this specialized scenario, the use is limited, as the maximum distance supported is only 15 meters and the physical connector interface used for 10GBASE-CX4 is not based on the more commonly deployed RJ45 physical interconnect. IEEE also included an option called "short reach" within their 802.3an 10 Gigabit Ethernet standard. It essentially allows ports on a switch or the Ethernet adapter of the server to power down elements of its internal circuitry if they sense a short distance (less than 30 meters). However, the short reach mode option will only operate using Augmented Category 6 or ISO Class E_A grade cabling. Augmented Category 6 may be used in this instance and may eclipse the use of 10GBASE-CX4 in the process, as these cables are an expensive twinaxial construction and require the use of a special connector. Standard Category 6/ISO Class E may not be used in this application, as the electrical characteristics are not suitable.

PROTECTION OF DATA CENTER ASSETS

Availability and longevity of data centers can be compromised by several factors such as fire, vandalism or even terrorism. The ANSI/TIA-942 standard provides information to planners regarding the protection of data center assets whether by means of physical security or fire prevention. It also recognizes the importance of providing manageable access control to data center facilities and monitoring of who is there and who is doing what. According to DuPont, approximately 323 non-residential fires and over seven million dollars of property damage occur each day. While improvements to fire safety practices, equipment and building materials can save lives, they can also protect assets.

Potential asset losses in data centers can create concern. The cost of downtime and computer equipment losses hit the top of the list of these concerns. Most data centers are protected by sophisticated air-sampling smoke and fire monitoring systems, pre-action, dry-pipe sprinkler systems and clean agent inert gas systems. Tiny smoke particles can become highly damaging to computer hard drives and storage systems so fire and smoke prevention is a key element of data center design. The informative “Annex G” of the ANSI/TIA-942 standard lists many guidelines and practical suggestions.

ENVIRONMENTAL MONITORING SOLUTIONS

ANSI/TIA-942 specifies a normal data center environmental operating range between 68 and 77 degrees Fahrenheit (20-25 degrees Celsius) with a sustained humidity level of 40 to 55 percent. Also, any change in the environment should never exceed nine degrees per hour. Humidity control is a key objective for minimizing static charge buildup on equipment and infrastructure. Accidental static discharge can produce high voltages that can seriously damage sensitive microprocessors.

In addition to protecting valuable computer equipment from smoke and fire damage, temperature and humidity are key factors to consider when uptime and equipment longevity are strong objectives as they are in the data center.

Additional challenges to uptime can present themselves as a result of human error, power spikes or even sabotage. The TIA data center standard addresses security concerns and recommends video surveillance of parking lots, perimeters, support equipment rooms and of course, the computer room itself. Some data center planners and operators actually run all of their cabling overhead not only to simplify connectivity changes, but to constantly monitor and record any physical work or changes done to fiber or copper infrastructure. This approach allows the Network Operations Center to quickly find or rule out possibilities when troubleshooting service disruptions or outages. Additionally, there are many ways to control data center access and the ANSI/TIA-942 standard contains recommendations and security tiers to aid in upfront planning.

DATA CENTER STANDARDS SUMMARY

ANSI/TIA-942 is a comprehensive document that provides data center planners with guidelines for design, construction and expansion within telecom, electrical, architectural, mechanical and security areas. It provides mandatory infrastructure standards and informational guidelines presented by levels of performance and availability known as "tiers." The ANSI/TIA-942 is an excellent vehicle for communication among data center professionals and provides tremendous value by addressing many previously disparate topics in one document.

The ANSI/TIA-942 is a standard that gives guidelines for the design and installation of a data center. The standard specifies:

- Cabling design
- Network design
- Facilities design
- Informative annexes containing "best practices" and availability requirements
- Spaces
- Pathways
- Racks/cabinets.

This is the base standard you will want to familiarize yourself with so you will know important information including the basic elements of a data center cabling plant or the four tiers of data center redundancy. Other standards to reference for products in your data center include the following.

IEEE 802.3an (10GBASE-T TASK FORCE)

The IEEE 802.3 family of standards deals with Ethernet. 802.3an specifically deals with 10 Gigabit per second Ethernet or 10GBASE-T. The standard tells the manufacturers how to build 10 Gigabit Ethernet equipment, and it also gives recommendations for the cabling required to run 10 Gigabit Ethernet. It specifically mentions ANSI/TIA-568B.2 (ad10) and ISO Class E_A.

ANSI/TIA-568B.2 (AD10) – AUGMENTED CATEGORY 6 TRANSMISSION PERFORMANCE AND ISO 11801 CLASS E_A

Both of these standards are cable, component and channel standards for 10 Gigabit Ethernet. Running 10 Gigabit Ethernet over copper requires higher bandwidths and uses all four pairs at once. This has introduced new issues such as alien crosstalk, which is taken into account in the new standards. An important note about the ISO standards is that its proposed standard for cabling infrastructure for 10 Gigabit Ethernet is more stringent than the TIAs. Anixter's Lab tests to the tougher ISO requirements.

IEEE 802.3af AND 802.3at POWER OVER ETHERNET STANDARDS

These standards allow for running power over the same cabling plant as data to support IP phones, WLAN access points and many other devices. 802.3af is the current standard that allows for up to 12.95 watts of power at the end device. The proposed 802.3at standard would raise that power to a minimum of 30 watts and up to 70 watts. This is important for powering devices like motors for Pan/Tilt/Zoom (PTZ) cameras.

ANSI/TIA-569-B COMMERCIAL BUILDING STANDARD FOR TELECOMMUNICATIONS PATHWAYS AND SPACES

A lot of time is spent considering the electronics and cabling that go in a data center. It is just as important to spend time designing the pathways and spaces for that equipment and cabling. The pathways and spaces of a data center will outlast the cabling and equipment. As a result, much thought must go into preparing them for future technologies. This standard defines and specifies areas such as service entrance pathways and firestops. In this standard, you can find discussions on the lighting, HVAC and access to the telecommunications closet. You will even find the maximum amount of dust that can be found in the air within the data center.

For more detailed information on networking standards, order Anixter's Standards Reference Guide at anixter.com/literature (North American or European version).

ANSI/TIA-606-A ADMINISTRATION STANDARD FOR THE TELECOMMUNICATIONS INFRASTRUCTURE OF COMMERCIAL BUILDINGS

Moves, adds and changes are constant in any communications system. The data center is at the center of all of these moves. The key part of this standard is identification and labeling. Standard labeling will make it easy for any technician to identify each part of the system. The standard also covers elements such as records and work orders.

ANSI-J-STD-607-A-2002 COMMERCIAL BUILDING GROUNDING AND BONDING REQUIREMENTS FOR TELECOMMUNICATIONS

Data centers are collections of very expensive and complicated electronic devices. These systems require a reliable electrical ground-reference potential. Grounding by attachment to the nearest piece of iron pipe is no longer satisfactory to provide ground reference for sophisticated active electronics systems. This standard shows how to properly ground data center equipment to provide personnel safety and a noise resistant electronic environment. Please reference EN50130 for grounding and bonding in Europe. Details can be found the Anixter's European Standards Reference Guide.

STANDARDS FOR POWER CABLES

For data centers located in the U.S., power cables and their installation must usually comply with the NEC as well as any applicable state or local codes. Although the NEC does not officially apply to installations of communications equipment under the exclusive control of communications utilities, virtually all utilities choose to comply to reduce their potential liability as well as their insurance premiums.

For Canadian installations, the Canadian Electrical Code (CSA C22.1) applies rather than the NEC (NFPA 70). The Codes of both countries require the use of specific UL Listed or CSA certified cables in each application. For example, cables installed in cable trays must meet certain fire test requirements to minimize fire propagation in the event of a fire. One power cable type frequently used in tray in U.S. data centers is NEC type RHH (per UL 44) with a "For CT Use" rating. This optional rating is based primarily on fire test performance and is one of many specific ratings that permit a cable to be installed in tray. Other optional ratings include ST1 (limited smoke) and LS (low smoke) ratings that verify a cable meets specific smoke emission requirements in UL 44. These ratings are not required by code. Data center power cables are also sometimes known as "KS spec" cables, which is a reference to central office power cable standards that have been in use for roughly half a century. KS power cable specifications are owned by Tyco Electronics Power Systems and include cable standards such as KS-24194™ and KS-22641™.

Other power cable and power cable installation standards often applicable to data centers include NEMA WC 70 (ICEA S-95-658), Telcordia GR-347-CORE, Telcordia GR-1275-CORE, ANSI/TIA-942 and ANSI-J-STD-607-A-2002. For European power cable requirements, please refer to page 22 of this guide.

DATA CENTER ASSOCIATIONS

The Uptime Institute

A source of information for design, installation and operation of a data center is the Uptime Institute. The Uptime Institute is a pioneer in the research and education of best practices for data center uptime reliability and improving uptime management in data center facilities and Information Technology organizations. The Institute maintains knowledge communities including the renowned Site Uptime Network®—a member community of Fortune 500 companies that learn from one another and through Institute-sponsored meetings and tours, research, benchmarking best practices, uptime metrics, and abnormal incidents. The Institute also offers public educational seminars, sponsored research and white papers on IT and facilities site infrastructure, uptime management including high density cooling performance, cold aisle/hot aisle design, Tier I, II, III and IV classifications, facility downtime, planning and critical physical layer design.

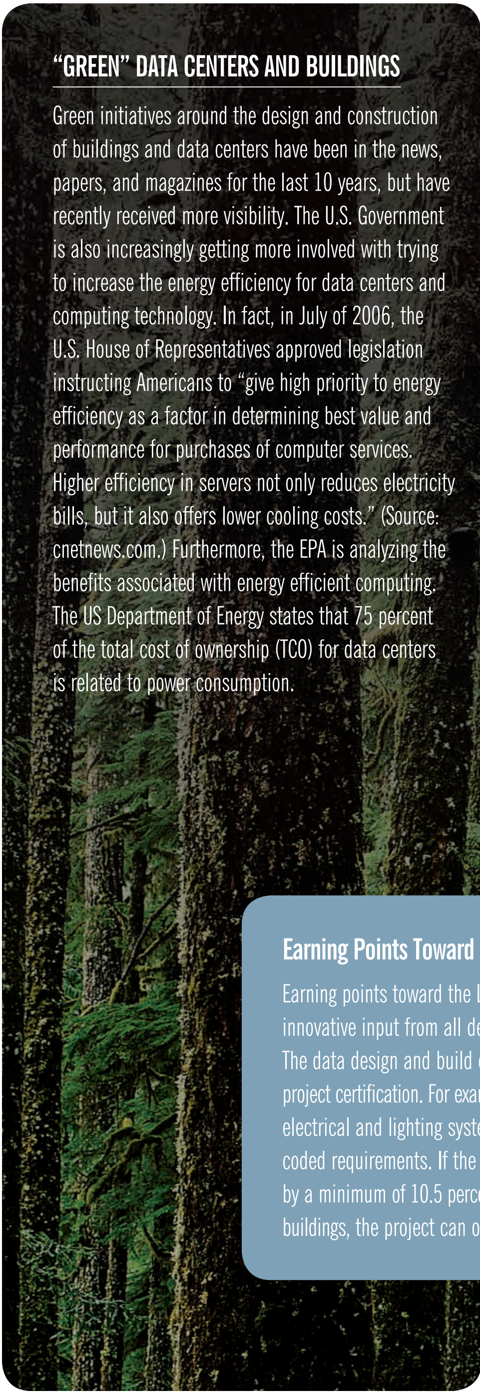
For more information visit uptimeinstitute.org.

AFCOM

AFCOM is a leading association for data center professionals, offering services to help support the management of data centers around the world. AFCOM was established in 1980 to offer data center managers the latest information and technology they need through annual conferences, published magazines, research and hotline services, industry alliances and more.

AFCOM is one of the most respected names in the data center industry, due in large part to its exceptional services and resources. The association's membership includes data center managers, MIS directors, CIOs and other IT professionals from Fortune 500 companies.

For more information visit afcom.com.



"GREEN" DATA CENTERS AND BUILDINGS

Green initiatives around the design and construction of buildings and data centers have been in the news, papers, and magazines for the last 10 years, but have recently received more visibility. The U.S. Government is also increasingly getting more involved with trying to increase the energy efficiency for data centers and computing technology. In fact, in July of 2006, the U.S. House of Representatives approved legislation instructing Americans to "give high priority to energy efficiency as a factor in determining best value and performance for purchases of computer services. Higher efficiency in servers not only reduces electricity bills, but it also offers lower cooling costs." (Source: cnetnews.com.) Furthermore, the EPA is analyzing the benefits associated with energy efficient computing. The US Department of Energy states that 75 percent of the total cost of ownership (TCO) for data centers is related to power consumption.

LEED (LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN)

Other organizations such as LEED have been around since 1999 and are increasing in popularity as well. LEED is a voluntary standard created by members of the U.S. Green Building Council for developing buildings that are environmentally responsible and are a healthy place to live and work. A LEED certification for a project illustrates a dedication to sustainability and energy efficiency. Acceptance of the LEED Green Building Rating System has grown considerably over the past 10 years and more jurisdictions and governmental agencies are requiring LEED certification for new projects. A building can earn points toward one of four levels of LEED certification through such project components as site selection, architecture and mechanical systems. The LEED certification also looks at other variables such as optimized energy performance, construction waste management, building automation systems (BAS), controllability and innovative design. More information on the LEED certification can be obtained by a LEED accredited professional or by visiting usgbc.org/leed.

Earning Points Toward LEED Certification

Earning points toward the LEED certification can be difficult and proper innovative input from all design and construction entities should be considered. The data design and build contractor can easily generate several points toward project certification. For example, through efficient design of the mechanical, electrical and lighting systems, energy efficient buildings can reduce energy coded requirements. If the building's energy use is less than the energy code by a minimum of 10.5 percent for new buildings and 3.5 percent for retrofit buildings, the project can obtain LEED points.

Please note: the LEED certification program does not apply in Europe at the present time.

SUMMARY

When it comes to the communications infrastructure, Anixter can make several specific recommendations. While the ANSI/TIA-942 standard for data centers specifies a copper minimum of Category 6 cabling, Anixter recommends cabling to support 10 Gigabit Ethernet in new data centers and during data center expansion. At minimum, a Category 6A construction is needed to provide bandwidth in the 500 MHz range with proven control of alien crosstalk.

Anixter continues to recommend fiber in all backbones including the data center. Laser-optimized, 50-micron is the fiber of choice—again to confirm the data center is ready whenever and wherever 10 Gigabit Ethernet becomes a requirement. Additionally, limited combustible cable has strong merit in limiting loss—both of life and property and may be a requirement when the NEC is updated in 2008.

It pays to use the latest security and monitoring technology to protect assets and uptime from internal and external threats. Video surveillance, access control and environmental monitoring are all areas where Anixter can provide its product expertise during the data center design and upgrade process.

Anixter understands the challenges facing today's data center professionals and embraces standards such as ANSI/TIA-942 whose goal is to provide a comprehensive roadmap for success. Anixter supports data center customers in achieving their goals of availability, reliability and operational efficiency.

SECTION 5

Key Considerations for Deploying Data Center Solutions

SUPPLY CHAIN SOLUTIONS AND DATA CENTERS

The foundation to an efficient data center deployment project is having a distribution network that you can leverage for product inventory and coordinating deliveries with installation resources. Data centers require materials from multiple manufacturers to arrive at the right place, at the right time, to be installed on-time and within budget.

Fundamental distribution services should include:

- The ability to view and allocate inventory in any warehouse globally
- A significant investment in a diverse breadth of inventory
- IT systems that provide customers real-time information
- Predictable delivery times and processes to help you plan your projects.

Anixter takes fundamental distribution a step further by applying "best practices" of supply chain principles to the industry and the reality we face every day with technology deployments.

Our common goal is to help you:

- Reduce costs
- Save time
- Improve productivity
- Improve efficiency
- Enhance financial performance
- Mitigate risk
- Create scalable and repeatable services.

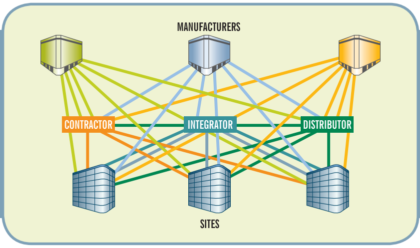
While a significant amount of time is spent on technological products, we believe that an additional conversation needs to happen regarding the process side of the project. Identifying the fixed costs as well as process inefficiencies associated with material management is important. Together, we can identify the challenges in material management.

"Poor supply chain design regularly increases project costs by 10 percent or more, and project duration might be similarly affected."—University of Florida

READY! SM Deployment Services by Anixter maps our distribution and Supply Chain Solutions to the construction or deployment process of any technology project. We combine sourcing, inventory management, kitting, labeling, packaging and deployment services to simplify and address the material management challenges at the job site(s). READY! Deployment Services by Anixter will help you improve the speed to deployment, lower your total cost of deployment and deliver product specifications are delivered as planned.

READY SM DEPLOYMENT SERVICES BY ANIXTER

Challenges in Technology Deployments: Managing Multiple Sources and Delivery Points



This model represents typical challenges we see in many data center deployments. These challenges include:

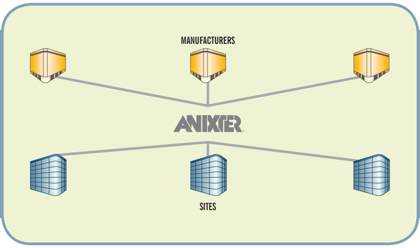
- Multiple OEMs are part of the build-out
- Multiple ways to get product to the job site
- Multiple aggregators (subcontractors, integrators, distributors, etc.) are involved.

The model incurs stress when you add more components (manufacturers, trades or sites). A complex situation like this one cannot seamlessly scale to meet the project demands. In fact, if the project demands increase, bottlenecks in service, support and expense become evident.

Every line on this diagram represents a point of risk: expense, coordination and/or failure. Anixter's Supply Chain Solutions minimizes the risk involved with technology deployments by coming up with a plan to:

- Deliver the right products, to the right place, with the right quantity, in the right condition, at the right time, every time
- Efficiently coordinate the processes: materials, manufacturers and trades
- Maximize installation productivity while minimizing delay/wait time
- Eliminate disruption to regular operations.

Anixter's Supply Chain Solutions: Minimize Process and Cost



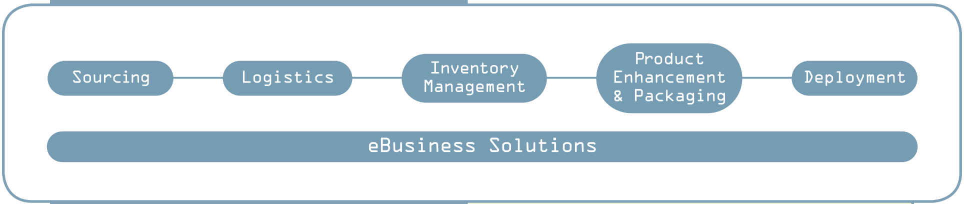
Material management matters. To improve on-time completion of the project, it is important to have an effective material management strategy. Putting a supply chain partner in the middle allows you to effectively manage the materials for one or multiple projects and scale to meet demand. A supply chain partner enables you to focus on your core competency.

Anixter can help you develop a well-defined program to minimize added costs while maximizing efficiency and reducing risk. We will work with you to complete the following:

- Evaluate all processes involved with material procurement, inventory management and project deployment
- Streamline order entry, material management, vendor consolidation, deliveries and material management at the job site
- Create a customized supply chain solution for your data center project

The Supply Chain Model: Scalable and Repeatable

The definition of "supply chain" is the efficient flow of goods, services and related information from the point of origin to the point of consumption.



To define the supply chain solution for technology deployments, we recommend you define key steps in the process. The baseline model above illustrates six key components a supply chain partner should address when building an effective solution for you. To scale to the project's demands, the model needs to be addressed as a whole, not just individual components.

The following information is a break-down of Anixter's Supply Chain Solutions model.

Sourcing

It is important to identify the product specifications at the beginning. It is just as important to identify all the products for each system that you will need for the project. Anixter has product and technical expertise to help during this step of the process to support a breadth of OEM supplier relationships. One of the questions during the sourcing process is who will be responsible for procuring the material? Our experience is that the answer will include the data contractor/ integrator, electrical contractor, security integrator and end-user. Coordination of deliveries to these buying groups will be handled at the deployment phase of the supply chain model.

Logistics

This step in the process is primarily concerned with lead time management of the products into our distribution facility. As with any project, there are multiple manufacturers and products. One of Anixter's core competencies is to effectively manage the volume of work associated with inbound logistics to our warehouse, making sure we have the product in stock when and where you need it.

Inventory Management

This is the heartbeat of the supply chain offering. Anixter's ability to manage piece part detail and inventory is the basis of our fundamental distribution model. Anixter currently stocks more than $1 billion of products throughout our warehouse network. The inventory management system throughout our warehouse network is a single platform and can be customized to catalog the products specific to your project. Anixter's investment allows our customers to leverage our experience to create a scalable, repeatable, cost-effective solution.

Product Enhancement and Packaging

Here is the question: What can we do at the warehouse (prior to shipment) that can make material management at the job site easier and more cost effective? Anixter services offered at the warehouse include kitting, pre-assembly, labeling, special packaging requirements, etc. We can work with you to define your scope of work.

Deployment

The product has been sourced, inventoried and packaged. Now it is time to assess the deployment schedule. What are the delivery requirements? How will we build the piece of the model to scale to the project demands and support multiple trades? Anixter can leverage its current relationships with transportation companies to meet your expectations.

eBusiness

Every process needs visibility. We can provide you with a customer view of key events in the supply chain model. Think of this as your view into our warehouse network, inventory and shipping information. Additionally, anything on our system can be "mined" from the database to provide you key measurements and reports.

ANIXTER'S SUPPLY CHAIN SOLUTIONS IN ACTION

When a large financial institution was refreshing its data center infrastructure, it built a plan to complete the deployment in three specific phases. The project required four different cabinet configurations for each phase over a 12-month period.

Project managers realized that material availability was critical to a successful installation; prior experience proved that running out of materials (stock-outs) caused delays and that productivity was reduced when installers were missing components. This effect (called "go backs") added unproductive labor hours and had the potential to delay the completion of each phase.

Anixter was invited to participate in the project as a supply chain partner. After discussing the project's comprehensive bill of materials, timeline and installation procedures, Anixter developed a supply chain solution that would support the installation process in the most effective way.

Designs were supplied for each type of cabinet depending on the equipment to be housed in it—servers, switching gear, and copper and fiber MDFs. Each cabinet had a specific bill of materials and detailed plans on how the product was to be mounted in the cabinets. Anixter created specific part numbers for each cabinet type to confirm the corporate specification and streamline the ordering process.

The following is an account of each step in the supply chain process and how we built the final solution for the customer

Sourcing

Anixter stocked the majority of the products specified. However, the customer asked us to include some products that it already owned. We received and stored the customer-owned material in our warehouse. We also created a unique part number to identify each type of cabinet as one all-inclusive part number, including the Anixter-provided and customer-owned material. Purchasing one part number for a complete cabinet instead of placing orders for multiple products from many sources reduced personnel and simplified processes needed to manage the purchase orders.

Logistics

The project's success relied on timely delivery of all materials to the job site according to the project's phases. Anixter took control of managing the lead times of the multiple manufacturers specified for the project. Our job was to make sure everything was in stock, and not delay the down stream deployment of these product solutions.

Product Enhancement and Packaging

To maximize efficiency, we identified tasks that could be done at the warehouse prior to shipping the product. Cabinets were preassembled with patch panels, wire management, power strips and other equipment mounted according to the customer's specifications. Additionally, kits with all necessary components were also created and included in the same shipment.

All components were packed together, color-coded and clearly labeled to confirm that the material was easy to identify at the job site.

Deployment

Because delivery took place in the city, a transportation solution was carefully chosen to meet specific delivery times. The material then could be unloaded at the available dock and taken via the freight elevator directly to the specific point of installation.

To oversee the process and avoid delays, we assigned a Supply Chain Program Management Specialist to the project. The specialist coordinates efforts with the contractor's project management team and different suppliers to make sure all materials arrived as defined to the job site according to schedule.

KEY BENEFITS TO THE CUSTOMER

- Anixter's Supply Chain Solutions helped the customer, consultants and contractors reduce the overall cost of deployment and deliver a project on time and on budget.
- Consolidating purchases and aggregating all products into one unique part number simplified the ordering, tracking and management process.
- Having Anixter manage the lead times and store materials in one warehouse until it was needed for installation reduced the upfront inventory investment needed by the customer.
- Anixter's logistics expertise in coordinating deliveries, even in challenging conditions, helped keep the project on track.
- Product preassembly and whole order delivery minimized the need for storage and staging space at the data center and also allowed the contractor to dedicate highly skilled personnel to focus on his primary mission of building the infrastructure for the data center without increasing the overall cost to the customer.

Thanks to an efficient and predictable supply chain, all three phases of the project were completed

MATERIAL MANAGEMENT MATTERS

Addressing material management and its affect on the supply chain can be the fundamental difference of success for your project. Anixter understands that there are many challenges with building a data center including selecting the right technology, properly designing the data center, and determining the right contractors and integrators to complete the installation.

As you design your data center, Anixter can help you look at the deployment process to maximize your installation and on-time completion of the project. We do this by addressing the material management challenges at the job site before the material arrives.

As you look at your data center project deployment, ask yourself these questions regarding Supply Chain Solutions:

- What potential delays in your project have you identified with regards to material management?
- Do you anticipate an acceleration of time frame or an increase of scope in work for the data center build-out?
- What is the plan to deliver material to the job site for the IT and security infrastructure solutions and the contractors/integrators who will install them?
- What is your plan to manage the lead times for all the products involved and how will you make sure they are delivered on time?
- What sections of the data center could you "kit" or preassemble prior to delivery that would minimize the risk of the material at the job site? These sections could include server cabinets, KVM cabinets, MDF copper, MDF fiber, switch cabinets, etc.

Anixter's Supply Chain Solutions can be modified to your specific project and can scale to meet your project demands. Whether you are building one large data center or consolidating multiple data centers into a select few, we can create a process together that will allow you to deploy an effective supply chain solution.

APPENDIX
About Anixter

THE ANIXTER DIFFERENCE

We are proud to serve more than 100,000 customers across 50 countries every day with our world-class inventory, global capabilities, technical expertise and Supply Chain Solutions. Our three specialized sales forces focus on Enterprise Cabling & Security Solutions, Electrical and Electronic Wire & Cable and Fasteners.

- We stock more than 400,000 items from the world's premier manufacturers and move them cost effectively through our global distribution network that encompasses more than 6 million square feet of distribution space.
- We view technical know-how as an essential part of our value to our customer. Whether you are dealing with our Enterprise Cabling & Security Solutions, Electrical and Electronic Wire & Cable, or our Fasteners division, you can count on Anixter for reliable up-to-date technical advice and assistance.
- With a wide variety of Supply Chain Solutions to choose from, we provide our customers the opportunity to save money by increasing their ability to be efficient and to avoid costly delays.

OUR GLOBAL CAPABILITIES

We are very proud of the quality products we distribute (over $1 billion of inventory from best of class manufacturers), but the reason our customers count on us day in and day out is not just about world-class, quality products. Our customers know they can count on Anixter to deliver consistent, superior service and support around the world. And when we say we are global, we mean it. We do not just ship products from the U.S. to various countries, we stock inventory in each country and we are specialists at moving inventory across borders efficiently and cost effectively. Anixter is located in 50 countries around the globe, and our sales specialists in-country are familiar with the trends and needs in the local market, as well as the local currency, standards and customs. We speak 30 different languages to serve our customers' diverse needs.

OUR PRODUCTS

It seems simple enough: you need something, you call a distributor and buy it. Unfortunately, nothing is really that simple. In the real world, there are complicated systems, small parts, and constantly changing technical developments and requirements. Just determining what you need can be an all-consuming process, one that is only aggravated by hard to find or out of stock items. Missing a crucial component can significantly add costs and delays to your projects.

At Anixter, we take the worry out of Just-in-Time product availability. We maintain more than $1 billion in our global inventory, and the product expertise you need to make sure you get the right product, when and where you need it.

Anixter is the distributor to call on if you need products and solutions for:

- Network cabling (copper and fiber)
- Security (video surveillance, access control, door locking hardware)
- Electrical wire and cable (power cable)
- Electronic wire and cable (coax, multi-pair, multi-conductor cable, etc.)
- Networking, wireless, and voice electronics
- Fasteners and other small components ("C" Class).

OUR SUPPLY CHAIN SOLUTIONS

The purchase price of a product is not the only place to look to reduce costs in your business. Effective management of your supply chain process will give you the greatest cost benefits.

Anixter's Supply Chain Solutions were developed to respond to our customers' needs for a business partner, not simply a product provider. To service each customer's unique needs, our Supply Chain Solutions is focused on the complete supply chain process–from sourcing to delivery–rather than just the product purchase.

OUR SUPPLY CHAIN SOLUTIONS OFFERING

Our modular service approach allows us to customize our Supply Chain Solutions solution to fit your specific needs.

- **eBusiness Solutions:** Anixter's superior eBusiness capabilities are available for integration with your own supply chain systems, to provide real-time transactions and information and unmatched visibility to all aspects of the supply chain.
- **Sourcing:** Our product knowledge and manufacturer management services can reduce the time and resources you spend while we secure the products you need.
- **Logistics:** Your material handling and transportation management responsibilities can be optimized with our logistics services.
- **Inventory Management:** Our Supply Chain Services customers realize a reduction in investment, space and personnel needed for receiving, storing and managing inventory.
- **Product Enhancement and Packaging:** Maximize the use of specialized labor by eliminating product preparation and non-essential, on-site assembly.
- **Deployment:** We coordinate all materials and enhancement processes for on-time delivery in one or multiple locations, to let you focus on your core business.

OUR TECHNICAL EXPERTISE

Across the world, we have more than 2,600 sales specialists who support our customers. We have three specialized sales forces that focus on enterprise cabling and security systems, electrical and electronic wire and cable, and fasteners. These sales specialists have years of experience in specifying products and solutions for customers. Our salespeople are well trained to truly identify and understand your needs and requirements.

Anixter's expert Systems Engineers (SEs) receive ongoing, extensive training about new products, technologies, applications and market trends. In addition, many of our SEs participate in local standards and industry committees and associations, which keeps them current on the latest standards being introduced into the market. Anixter also employs over 126 RCDDs (Registered Communications Distribution Designer), the highest networking infrastructure design certification.

In every part of our business, we welcome the opportunity to support our customers' purchasing decisions. You can rely on our technical experts to keep you current on the latest products, applications, industry trends, standards and emerging technologies.

THE ANIXTER INFRASTRUCTURE SOLUTIONS LAB

Anixter's Infrastructure Solutions Lab℠ allows us to actively demonstrate the best practical technology solutions from best in class manufacturers in the areas of enterprise cabling solutions, video security and access control systems for our customers. Our mission for The Lab is simple—educate, demonstrate and evaluate.

- Educate customers on the latest security and networking best practices, standards and technologies being deployed in the networking and security market.
- Demonstrate the latest enterprise cabling and security solutions available from our manufacturer partners.
- Evaluate our network infrastructure and security solutions to confirm that our customers are selecting the right systems for their specific needs.

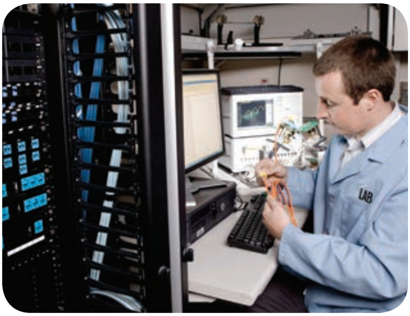
We are continually testing products in our Lab to confirm:

- Quality products are recommended and delivered to our customers
- Consistency of performance across product lines and within systems
- Interoperability of products and systems to help customers can integrate systems and follow the trend toward convergence.

THE LAB
ANIXTER'S INFRASTRUCTURE SOLUTIONS LAB

Networking and Security Product Testing at Our Lab Includes:

- Random performance testing of Anixter inventory to confirm quality of standards compliance
- Network throughput and interoperability testing
- Copper and fiber cabling compliance verification (TIA, ISO/IEC, IEEE)
- Customer proof of concept
- Application testing
- 10 Gig Ethernet testing
- Video over IP, video quality and bandwidth utilization
- Power over Ethernet capability and verification
- Digital compression image quality vs. analog technology testing
- Evaluation of analog and IP cameras, video management software evaluation, DVR, NDVR and NVR products.



Anixter can assist you with all of your infrastructure needs to support your data center solutions:

- Racks, cabinets and shelving products
- Pathway and raceway products
- Cable management products
- 10 Gigabit Ethernet and Augmented Category 6 cabling solutions
- Fiber solutions
- Pre-terminated fiber solutions
- Intelligent infrastructure solutions
- Power distribution products
- UPS and power protection products
- Intelligent power strips and rack/cabinet-mounted PDUs
- Environmental monitoring and management products
- KVM switches and console managers
- Patch cords and bulk cabling
- Grounding and bonding products
- Supplies (firestop, cable ties, consumables, etc.)
- Power cabling and accessories
- PoE devices (in IDF and telecom closet)
- Access control and surveillance systems and devices
- Test equipment
- Tools

You can find a comprehensive listing of these products in our print or online catalogs.
Order a copy of our print catalogs at anixter.com/literature
or visit our online catalog.

Anixter University.
Data Center College.

Data Center College

Anixter's Data Center College (DCC) is a free and unique educational institution with a curriculum designed to create awareness and to provide general solutions for current and future data center infrastructure issues. Topics covered include 10 Gigabit Ethernet, wireless, Power over Ethernet, thermal management, access control and video surveillance, just to name a few. The format for DCC brings a comprehensive array of technical and informational courses directly to the customer's site.

Visit anixter.com/au to learn more about DCC or to register for a class.

Anixter is located in 260 cities in more than 50 countries.

See if Anixter is located in a city near you at the end of this guide.

Anixter would like to acknowledge the following companies for their contributions, either directly or indirectly to this guide:

- Avocent
- Corning Cable Systems
- DuPont
- iTracs
- SYSTIMAX® Solutions

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Anixter's Global Presence

Anixter is located in over 260 cities around the world in more than 50 countries.

Anixter Association and Committee Memberships

- Telecommunications Industry Association (TIA)
- International Organization for Standardization (ISO)
- Institute of Electrical & Electronics Engineers (IEEE)
- Open Network Video Interface Forum (ONVIF)
- Building Industry Consulting Services International (BICSI)
- Security Industry Association (SIA)
- Control Systems Integrators Association (CSIA)

Technical Certifications

- More than 100 Registered BICSI RCDDs
- PSPs (Physical Security Professional Certification)
- CCNAs (Cisco Certified Network Associate)

Corporate Snapshot:

Year founded: **1957**
Number of employees: **Over 8,200**
2011 Revenues: **$6.1 billion**
Products: **More Than 450,000**
Inventory: **Over $1 billion**

Customers: **Over 100,000**
Stock symbol: **AXE**
Countries: **More Than 50**
Fortune 500 List

NORTH AMERICA – USA

Worldwide HQ
Glenview, IL
224.521.8000

CANADA HQ

Toronto, Ontario
905.568.8999

LATIN AMERICA HQ

Glenview, IL
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Fasteners HQ
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ASIA/PACIFIC

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South Pacific HQ
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INTERNATIONAL SERVICES

Glenview, IL
224.521.8000

AFTER HOURS

USA
800.323.8167

Canada
800.361.0250

USA

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LATIN AMERICA

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Capelle aan den IJssel
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Poland
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Portugal
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Gothenburg
Stockholm
Switzerland
Montreux
Zurich
Turkey
Istanbul
United Arab Emirates
Dubai
Oman
Qatar

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New Delhi
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Taiwan
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Bangkok
Vietnam
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ANIXTER

Electrical and Electronic Wire & Cable • Enterprise Cabling & Security Solutions • Fasteners

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Anixter is a leading global supplier of communications and security products, electrical and electronic wire and cable, fasteners and other small components. We help our customers specify solutions and make informed purchasing decisions around technology, applications and relevant standards. Throughout the world, we provide innovative supply chain management solutions to reduce our customers' total cost of production and implementation. A NYSE-listed company, Anixter, with its subsidiaries, serves companies in more than 50 countries around the world. Anixter's total revenue approximated $6.1 billion in 2011.