Data Center Design and Infrastructure Considerations

Data Center Design and Infrastructure

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Introduction

As the nerve centers of the digital economy, data centers enable organizations to conduct business around the clock and around the world. Housed in special environments with the latest advancements in computing technology and business innovation, data centers centralize and consolidate information technology (IT) computer resources. Whether you have plans to build a new data center or to upgrade an existing one, proper design and careful planning are crucial to ensure your system can support your network needs for today and the future as well as help you meet some of the requirements of global regulations such as Sarbanes-Oxley.

With more than 3 trillion bits of data created every second, the world's appetite for more feature-rich information keeps growing, and with it, the need for data centers to store and process that information. However, as the worldwide pool of data grows, corporations are increasingly challenged with ensuring their corporate data centers can deliver the computing resources necessary to support their critical business applications without compromising power and cooling efficiencies as well as overall availability.

With the growth rate for data centers at roughly 50 percent a year, an increasing number of businesses are demanding video, voice and data systems to be managed over one converged network. As the role of the data center becomes even more critical, a data center should be designed as a secure, intelligent, flexible and scalable IP platform to enable communications, security and building systems to interoperate seamlessly.

Some of the key areas to consider when designing your data center include:

- Data cabling
- Grounding and bonding
- Infrastructure management and monitoring
- Power and cooling
- Thermal management
- Security

The Modern Data Center

To maintain this constant performance, data centers are hardened facilities dedicated to providing uninterrupted service to business-critical data processing operations. Among their 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

These physical infrastructure considerations should be addressed to ensure a data center is designed to meet the complex IT challenges facing organizations today.

Types of Data Centers

Data centers fall into two major categories: 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 is to support data processing and Web-oriented services for their own organizations, business partners and customers. In-house IT departments or contractor partners typically support and maintain the equipment and applications for the data center.

Internet data centers are primarily owned and operated by traditional telcos, unregulated competitive service providers or other types of commercial operators. Each operator, however, has similar goals – to provide outsourced information technology 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 e-commerce. 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.

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
- Fail-safe power
- HVAC and fire suppression
- High-performance cabling infrastructure
- Physical security (access control, video surveillance, etc.)

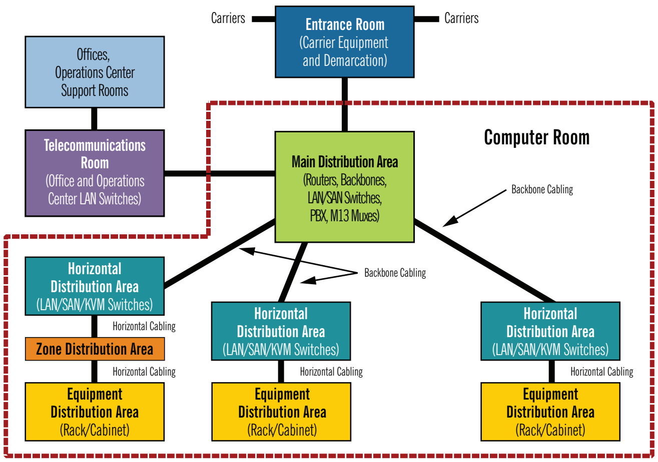
TIA-942 Standard

With its publication in 2005 by the Telecommunications Industry Association (TIA), the TIA-942 Standard became the first industry standard that focused on physical layer infrastructure design for data centers. Until the publication of this standard, organizations were generally relegated to using their established internal best practices to plan, design and construct new data centers. With an industry standard in place, designers and planners now have guidelines that were derived from the consensus of industry participants from the end-user, manufacturing, consulting and contractor communities. The TIA-942 is the most comprehensive standard of its kind, incorporating elements of the well known TIA-568 communications cabling standards, mechanical and electrical support systems, grounding and bonding, and physical security systems.

Layout Considerations

The TIA-942 Standard adopted the established wiring practices of the TIA-568 series of wiring standards as a key design philosophy. With the advent of Ethernet as the de facto protocol for IP-based communications networks, the TIA-568 series has been highly successful during the last two decades. The basic elements of the data center structured cabling system include the following:

- Horizontal cabling
- Backbone cabling
- Cross-connect in the entrance room or main distribution area
- Main cross-connect (MC) in the main distribution area
- Horizontal cross-connect (HC) in the telecommunications room, horizontal distribution area or main distribution area
- Zone outlet or consolidation point in the zone distribution area
- Outlet in the equipment distribution area



Sub-head Rack and Cabinet Placement

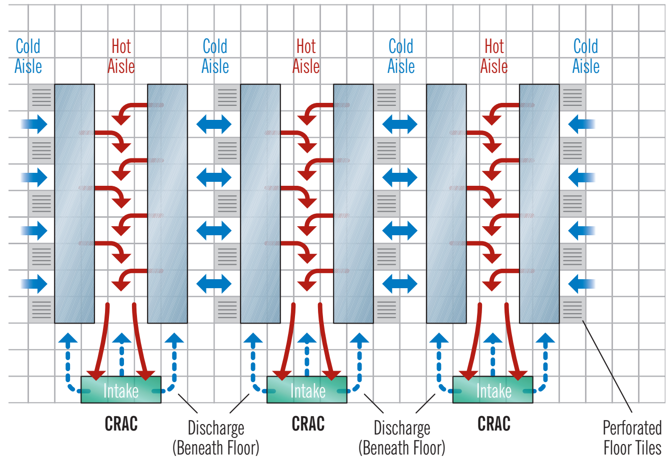
Cabinets and racks should be arranged in an alternating pattern, with the fronts of cabinets and racks facing each other in a row to create "hot" and "cold" aisles.

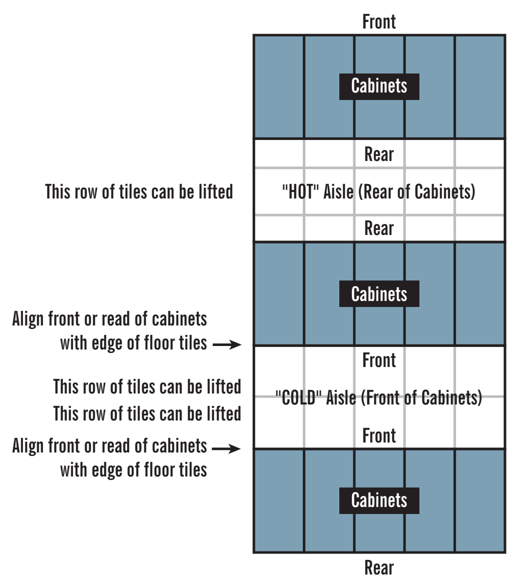
Cold aisles are in front of racks and cabinets. If there is an access floor, power distribution cables may be installed here under the access floor on the slab.

Hot aisles are behind racks and cabinets. If there is an access floor, cable trays for telecommunications cabling may be located under the access floor in the hot aisles.

In order to ensure optimal thermal efficiency when using perimeter computer room air-conditioning (CRAC) units, it is ideal to locate the CRACs perpendicular to the hot aisle. This allows for a short return path for the exhaust air exiting the rear of the server or network cabinets back into the intake of the CRAC units.

A minimum of 1 m (3 ft.) of front clearance shall be provided for installation of equipment. A front clearance of 1.2 m (4 ft.) is preferable to accommodate deeper equipment. A minimum of 0.6 m (2 ft.) of rear clearance shall be provided for service access at the rear of racks and cabinets. A rear clearance of 1 m (3 ft.) is preferable. Some equipment may require service clearances of greater than 1 m (3 ft.).





Uptime Institute Tier Levels

A source of information for design, installation and operation of a data center is the Uptime Institute, which has been a leader in the research and education of best practices for uptime reliability and management in data center facilities and IT 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.

As an important aspect of its research efforts, the Uptime Institute created a ratings system that established a framework of performance "tiers" that directly correlate to the availability or resiliency of a data center. Higher reliability relates directly to higher construction costs. The chart below, which is from an Uptime Institute white paper, shows the tiers side by side and compares numerous features and benefits with Tier I being the lowest availability data center and Tier IV being the highest. 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. 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.

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

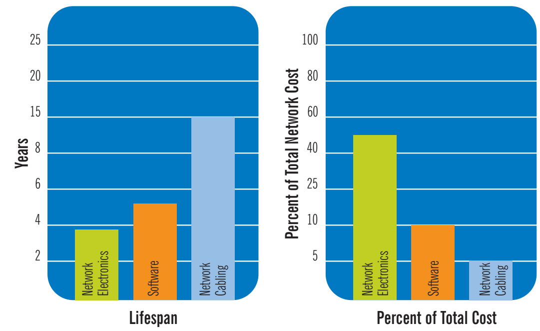
In addition to the general information provided by the ANSI/TIA/EIA-942, the informative "Annex G" contains several approaches to data center tiers in the following areas:

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

Communications Cabling Infrastructure

Choosing the appropriate cabling media can affect many aspects of a data center's design. An entire project or facility must be considered with respect to a system's and manufacturer's 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 disruptions. 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.



Cost Compared to Lifespan

The ANSI/TIA/EIA-942 standard recommends ANSI/TIA Category 6/ISO Class E as the bare minimum for network equipment requiring twisted-pair copper cabling. Category 5 and Category 5e/ISO Class D are not recommended for use in data centers because neither will support 10 Gigabit Ethernet. The Institute of Electrical and Electronics Engineers (IEEE) has completed extensive work on the 10 Gigabit Ethernet standards for both copper and optical cabling media. As 10 Gigabit Ethernet becomes more widely used, data centers will benefit from the increased data rates associated with this technology. Within the ISO/IEC 24764, a minimum of Category 6A (ISO Class E_A) copper cabling should be installed.

From a copper cabling perspective, any-to-any patch fields and high-performance copper patch cables make data center management and operations very economical and efficient. The TIA/EIA-568-B-2-ad 10 standard for Augmented Category 6 (Category 6A) twisted-pair or ISO 11801 Class E_A cabling channels will provide the best investment protection for data centers because many servers, and potentially storage area networks (SANs), will ultimately be connected through copper-based, 10GBASE-T-enabled local area networks (LANs) and SANs. With storage networks, 10GBASE-T presents some opportunity for creating IP-based SAN infrastructures utilizing the Internet Small Computer System Interface (iSCSI) or Fibre Channel over Ethernet (FCoE) protocols as an alternative or in addition to traditional Fibre Channel networks. 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/EIA-942 recommends laser-optimized multimode 50-micron/ISO OM3, although the standard permits 62.5-micron/ISO OM1 as well as single-mode/ISO OS1 fiber types. Fiber can also provide up to 60 percent space savings over copper cabling. This can be an important factor in areas of the data center where equipment density and heat dissipation are a concern. When the space below access floors becomes crowded, it can seriously restrict airflow needed for cooling. 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).

Power Cabling Infrastructure

Power distribution infrastructure is a critical component of data center reliability and efficiency. Power infrastructure design is becoming more complex as power demands rise, energy costs rise and owners shift emphasis toward green data centers. The industry is also considering a fundamental change in the method of delivering power in the forms of direct current (DC) or higher voltage alternating current (AC) systems. Combined with the redundancy requirements of higher-tier data centers, the design requirements for power distribution within the data center demand as much attention as the networking, storage and security systems.

Operating costs of a dedicated data center are becoming dominated by power requirements. As watts-per-foot densities increase, heat loads and their relative cooling requirements increase. According to the EPA, it is possible to see power usage consume 70 percent of a data center's post-construction operating cost. Proper routing of raceways to improve cool airflow, proper sizing of conductors to reduce power loss and heating, and well executed grounding to improve power equipment performance can all contribute to measurable reductions in total power consumption.

DC power delivery has the potential to reduce losses associated with energy wasting power supplies, which convert electric power from AC to DC. However, DC presents challenges such as voltage drop for systems under 50 volts, lack of readily available equipment, lack of user familiarity and incompatibility with much of the modern power distribution infrastructure.

Another method of reducing power losses as well as increasing power density in a data center is to deliver power with higher voltages in three-phase power distribution methods. A three-phase 480-volt (400-volt European) power system can deliver 300 percent more power to equipment than a 120-volt (230-volt European) single-phase conductor of the same size. It will require one or two more conductors for either a three-phase four- or five-wire system. Per the EPA in North America, the increased power density and efficiency comes from a mere 66 percent increase of infrastructure to support the 300 percent increase in power delivered. Higher voltage systems also benefit from less voltage drop and corresponding power losses.

Regardless of which power infrastructure future data centers migrate to, the cabling infrastructure does not need to change much. Building wire for feeder and branch circuits are suitable for AC or DC power up to 600 volts. The number of conductors and the size may change, but the product type will not require a change. However, adding phase conductors for future expansion to utilize equipment at 208 volts (230 volts European) or even 480 volts (400 volts European) three-phase power will increase the flexibility of the data center power system to allow for future increases in power density.

In addition to the careful routing and planning of raceways relative to the overall data center layout and cooling plan, sizing of the raceways is an important consideration at the outset. Including extra power conductors in the construction phase of the data center provides the greatest level of preparedness for future needs. Another approach is to oversize the raceways and conduits to allow for the additional conductors.

Learn more about power in the data center. Order a copy of our white paper, "Energy Efficiencies and Environmental Considerations for the Data Center" at **anixter.com/energy.**

Grounding and Bonding

To meet the reliability and uptime requirements of a modern data center, traditional grounding and bonding methods, such as only using the third prong on a plug, are insufficient. Carefully designing an effective grounding and bonding system is essential for the safe operation, maximum efficiency and maximum performance of a data center. A highly successful bonding and grounding system requires installation before the balance of the infrastructure and networking systems are installed in the data center.

Even though some grounding and bonding systems are actually installed along with the raised floor or other metals in the data center, most new solutions, such as pre-engineered signal reference grids, are installed before the raised floor is inswtalled and are supplemental to the common bonding network (CBN) and third-prong approach. These types of redundant bonding and grounding systems increase reliability and act as additional "headroom" by serving as an additional low-impedance path to ground for unwanted noise or fault currents. Low-impedance grounding can protect people and sensitive networking equipment from transients caused by the failure of adjacent equipment, lightning strikes or other system issues.

Understanding the environment of the data center is critical to component choice. Single-hole lugs used for equipment bonding are more likely to spin when bumped during a move, add or change. This spinning can cause the bonding connection to become loose and intermittent, which is often the most difficult type of electrical problem to troubleshoot. Because bonding and grounding are part of the data center's electrical and communications systems, they play a large role in safety for workers. Because extra precautions must be taken when repairing bonding and grounding, troubleshooting is further complicated. If equipment moves or becomes loose due to frequent changes, the ground impedance can increase over time. These higher ground impedances reduce the effectiveness of draining noise out of a communications system. It also increases the risk of equipment damage because insufficient current is carried on the ground path to trip the circuit breaker, causing the current to travel through the equipment to an alternate ground path.

The image on the next page is an example of a bonding jumper kit used for ladder type cable tray. With two lug holes on each end, it can be used for cable tray or other adjacent metal framed equipment. The two-hole design reduces the likelihood of twisting and shifting when it is bumped during a move or service adjustment.

Bonding Jumper Kit example

Grounding should be intentional, visually identifiable, conservatively sized and redundant. Because grounding carries fault currents and undesired transients, it should be installed to direct these currents away from people and sensitive equipment. It should also bond to everything metallic, ensure electrical continuity through all structural hardware and provide ground points for electrostatic discharge. Because the grounding is completed before the balance of construction, it is difficult to add later. Future power requirements will significantly impact the grounding requirements. Therefore, during a data center's design, it is important to understand the future power needs and relative grounding requirements. The joint industry standard on telecommunications grounding and bonding requirements, J-STD-607-A (EN50310 and ISO/IEC 14763-2 in Europe), provides data center planners an industry reference document for designing these systems.

Physical Security

Availability and longevity of data centers can be compromised by several factors such as fire, sabotage, theft or even terrorism. The ANSI/TIA/EIA-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. Using the Uptime Institute Tier framework as a basis, the ANSI/TIA/EIA-942 standard makes recommendations on improving the physical security of the data center, which include CCTV recording frame rate, access control levels and hardware, and site selection.

Conclusion: Energy Efficiency and Environmental Considerations

In North America, the Environmental Protection Agency submitted a report to Congress in 2007 with its findings on data center efficiency. This report projects near-term growth on energy use in the data center, based on current trends and evaluates potential savings with efficiency gains. As reported, data centers today consume a significant amount of the nation's total energy supply. In 2008, the EPA estimated that number at 61 billion kilowatt hours (kWh) or approximately $4.6 billion in electricity cost.

As data center power consumption continues to grow, it impacts the business enterprise, power supply companies and the environment. With more efficient energy use in the data center, power supply companies will face less demand for excess power, which could help limit blackouts. It can also help reduce carbon dioxide outputs and other greenhouse gases. For the business enterprise, it can significantly save on energy costs. Higher density computing platforms, such as blade servers, require more power and cooling capacity to be delivered into a much smaller footprint than what may have been originally allocated within the data center for traditional IT systems. Careful consideration should be given to a thermal management and cooling strategy that optimizes air flow as well as ensures proper cooling capacity to the IT computing load. This is also important in a traditional data center utilizing hot-and cold-aisle arrangements. In these environments, there is generally poor separation of the chilled air supply and the hot air return streams that are generated as a result of higher density systems. All of these factors are increasing the public's awareness and global concerns of these current trends.

About Anixter

As a global distributor of communications products, Anixter has the knowledge and products to make a data center secure, productive and future-ready. Anixter can manage the entire process by providing comprehensive and timely knowledge of data center issues. Anixter can also help you select the best products for your applications, including sourcing and supplying the most progressive products and services in the industry.

In addition the selecting the proper products to build a reliable data center, Anixter can help with the deployment process of your project. The foundation to an efficient data center deployment project is having a distribution network leveraged for product inventory and coordinated 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.

To learn more about the topics featured in this white paper, consider Anixter's Data Center College. Anixter developed Data Center College (DCC) as a unique educational program to assist customers with designing and managing their data center effectively. The format for DCC is a comprehensive array of technical and informational courses. DCC topics include 10 Gigabit Ethernet, wireless, grounding and bonding, Power over Ethernet, thermal management, power distribution, intelligent infrastructure management, access control and video surveillance.

To learn more about Data Center College, go to **www.anixter.com/dcc**.

Anixter is a leading global supplier of communications products used to connect voice, video, data and security systems. Anixter is also a leading provider of electrical and electronic wire and cable, fasteners and other small components to build, repair and maintain a variety of systems and equipment. Anixter bundles products with its innovative Supply Chain Services to cut costs out of customers' business processes, and ensure they get the right product, the first time.

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