The Three Principles of Data Center Infrastructure Design

ADC

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Understand These Three Principles and You'll:

- Lower your total cost of ownership
- Support your future growth plans
- Reduce your risk of downtime
- Maximize performance
- Improve your ability to reconfigure

Your data center is the most critical resource within your organization. As you know, it provides the means for all storage, management and dissemination of data, applications and communications for your business. When employees and customers are unable to access the servers, storage systems and networking devices that reside in the data center, your entire organization can shut down. Millions of dollars can be lost in a matter of minutes for businesses like banks, airlines, shipping facilities and online brokerages. Faced with these consequences, IT executives today must optimize their data centers, particularly the network infrastructure. When you consider that 70 percent of network downtime can be attributed to physical layer problems, specifically cabling faults, it's paramount that more consideration be given to infrastructure design.

Within this white paper we introduce three principles, that when executed properly, will help you gain significant benefits and savings throughout the life of your data center.

The Three Principles of Data Center Design

When you understand the three principles of data center design, you are able to:

- Lower your total cost of ownership
- Support your future growth plans
- Reduce your risk of downtime
- Maximize performance
- Improve your ability to reconfigure

Principle 1: Space Savings

Environmentally controlled real estate is expensive. The cost of building a data center is more than $1,000 per square foot in some cases (see Table 1). Data center racks and equipment can take up an enormous amount of real estate, and the future demand for more network connections, bandwidth and storage may require even more space. With insufficient floor space as the topmost concern among IT managers today, maximizing space resources is the most critical aspect of data center design.

Reliability Tier	Tier I	Tier II	Tier III	Tier IV
Construction Cost/Square Ft	$450	$600	$900	$1,100
Annual Downtime (Hours)	28.8	22	1.6	0.4
Site Availability	99.671%	99.749%	99.982%	99.995%
Source: Uptime Institute				

Table 1. Construction Cost per Square Foot

Business environments are constantly evolving, and as a result, data center requirements continuously change. Providing plenty of empty floor space when designing your data center enables the flexibility of reallocating space to a particular function, and adding new racks and equipment as needed.

As connections, bandwidth and storage requirements grow, so does the amount of data center cabling connecting key functional areas and equipment. Ample overhead and underfloor cable pathways, as well as abundant trough space, are also necessary for future growth and manageability.

Reducing existing data center space is likely the most expensive and disruptive problem your organization can face. Expanding the physical space of a data center can cost more than the original data center build itself, requiring construction, movement of people and equipment, recabling, and downtime. Given these consequences, properly designing the data center for space savings at the start is essential.

Cabling and connectivity components of the data center infrastructure can have a direct impact on the amount of real estate required in your data center. High-density solutions require less rack, floor, and pathway space, which leave more room for flexible reconfiguration and growth.


Figure 1. Data Center with Flexible White Space

Principle 2: Reliability

Uninterrupted service and continuous access are critical to the daily operation and productivity of your business. With downtime translating directly to loss of income, data centers must be designed for redundant, fail-safe reliability and availability. Depending on the business, downtime can cost anywhere from $50K to over $6 million per hour (see Figure 2).

Figure 2. Financial Impact of Network Downtime per Business
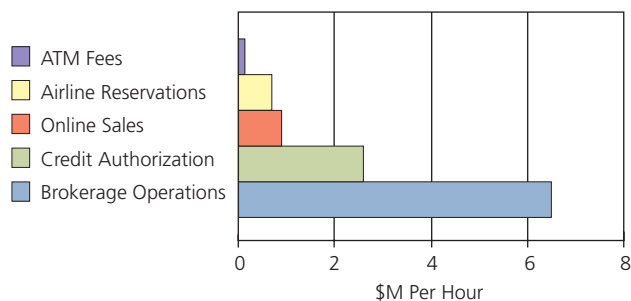
Source: Strategic Solutions

Data center reliability is also defined by the performance of the infrastructure. As information is sent back and forth within your facility and with the outside world, huge streams of data are transferred to and from equipment areas at extremely high data rates. The infrastructure must consistently support the flow of data without errors that cause retransmission and delays. Cabling and connectivity backed by a reputable vendor with guaranteed error-free performance help avoid poor transmission within the data center. A substandard performing data canter can be just as costly and disruptive to your business as downtime.

As networks expand and bandwidth demands increase, the data center infrastructure must be able to maintain constant reliability and performance. The cabling itself should support current bandwidth needs while enabling anticipated migration to higher network speeds without sacrificing performance. In fact, the data center infrastructure should be designed and implemented to outlast the applications and equipment it supports by at least 10 to 15 years. (Note that most active equipment is replaced every three to five years.)

The protection of cabling and connections is a key factor in ensuring data center reliability. Components that maintain proper bend radius throughout cable routing paths are critical to that protection. When cabling is bent beyond its specified minimum bend radius, it can cause transmission failures, and as more cables are added to a routing path, the possibility of bend radius violation increases (see Figure 3). Pathways must maintain proper bend radius at all points where the cable makes a bend — both at initial installation and when cables are accessed or added. The separation of cable types in horizontal pathways and physical protection of both cable and connections should also be implemented to prevent possible damage.
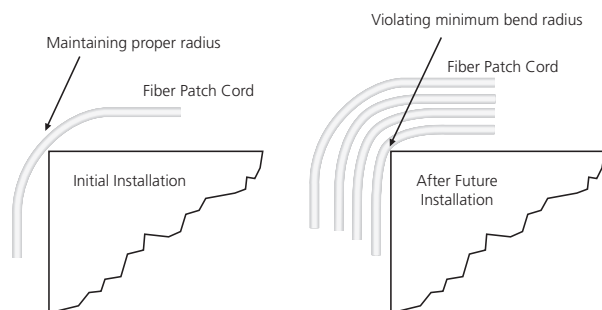

Figure 3. Care must be taken to avoid minimum bend radius rules when adding fibers

Principle 3: Manageability

Manageability is key to optimizing your data center. The infrastructure should be designed as a highly reliable and flexible utility to accommodate disaster recovery, upgrades and modifications. Manageability starts with strategic, unified cable management that keeps cabling and connections properly stored and organized, easy to locate and access, and simple to reconfigure.

Cable routing paths must be clearly defined and intuitive to follow while enabling easy deployment, separation, access, reduced congestion, and room for growth. This is especially important in data centers with large volumes of cables. Cables managed in this way improve network reliability by reducing the possibility of cable damage, bend radius violations, and the time required for identifying, routing, and rerouting cables.

The use of a central patching location in a cross-connect scenario provides a logical and easy-to-manage infrastructure whereby all network elements have permanent equipment cable connections that once terminated, are never handled again. In this scenario, all modifications, rerouting, upgrades, and maintenance activities are accomplished using semi-permanent patch cord connections on the front of the cross-connect systems (see Figure 4).
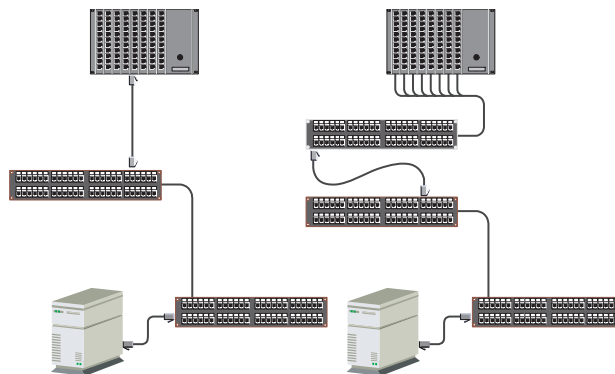

Figure 4. Interconnection vs. Cross-Connection

The advantage to deploying centralized patching in your data center include:

- Lower operating costs by greatly reducing the time it takes for modifications, upgrades and maintenance.
- Enhanced reliability by making changes on the patching field rather than moving sensitive equipment connections.
- Reduced risk of down time with the ability to isolate network segments for troubleshooting and quickly reroute circuits in a disaster recovery situation.

Deploying common rack frames with ample vertical and horizontal cable management simplifies rack assembly, organizes cable, facilitates cable routing and keeps equipment cool by removing obstacles to air movement. Cable management at the rack also protects the bend radius and manages cable slack efficiently. Connectors must also be easily defined and accessed for maintenance or reconfiguration with minimal disruption to adjacent connections.

Choosing the Right Mix of Equipment

Since the total spend for network infrastructure equipment is but a fraction of the entire data center cost, decisions for the so-called physical layer are often taken lightly. But the fact remains that 70% of all network downtime is attributed to the physical layer, specifically cabling faults.

When selecting fiber and copper cable, connectivity and cable management solutions for the data center, it's important to choose products and services that satisfy the three principles outlined here. A data center infrastructure without components that ensure space savings, reliability and manageability discounts the goal of optimizing the data center.

ADC's copper and fiber cable, connectivity, and cable management solutions come together to provide a comprehensive data center infrastructure solution that lowers total cost of ownership, enables future growth, and reduces risk of downtime.

- High-density copper and fiber solutions that take up less rack, floor, and pathway space.
- Guaranteed performance for reliable transmission and availability.
- Advanced cabling solutions ideal for today and for migrating to 10 Gigabit Ethernet tomorrow.
- Cable management solutions that protect cable and connections while offering easy identification, accessibility, and reconfiguration.

Copper Cabling

For years, copper UTP solutions have been the preferred network medium for horizontal cabling due to its cost-effective electronics, familiar plug-and-play connections, and easy installation. Data center horizontal cabling is no exception. As businesses evolve and data center needs grow, transmission speeds have migrated to accommodate huge streams of data being transferred back and forth between network equipment and servers.

ADC's TrueNet® CopperTen™ Augmented Category 6 cabling provides a copper system with the necessary characteristics to enable 10 Gbps Ethernet transmission over a full 100 meters. Additionally, CopperTen is backwards compatible to allow seamless migration from existing Gigabit Ethernet devices to 10 Gbps Ethernet in the future. For larger data centers where distances reach beyond 55 meters and transmission speeds are anticipated to reach beyond Gigabit Ethernet, CopperTen provides peace of mind that the cabling will support equipment and applications for many years. With CopperTen in the data center, you won't have to worry about recabling down the road.

High-performing Category 6 cabling solutions also have their place in the data center with the ability to support advanced applications, including 10 Gigabit Ethernet to a limited distance of 55 meters. ADC's TrueNet® Category 6 cable offers best-in-class performance with extra bandwidth and guaranteed zero bit errors. In the data center, the smaller diameter of TrueNet Category 6 cable saves as much as 32% of available cable pathway space. TrueNet Category 6 cable offers valuable data center space savings, reliable performance, and easier cable management.

Fiber Optic Cabling

With the same percentage of terminations as copper, fiber optic cabling and connectivity is a significant part of the data center. Fiber links are also the most critical links because they carry data to and from a large number of sources, including outlying telecommunication rooms and the outside world. Some data center designers tend to underestimate fiber optic cabling requirements, believing that a few strands will suffice for current and future needs. But emerging technologies continue to be layered onto the network, and because fiber optic cabling is backward, and not forward compatible, designers should choose the fiber type capable of supporting all the current and future applications in the data center.

Laser optimized 50μm multimode fiber was created as the industry moved to 10 Gbps Ethernet. Traditional LED signaling technology could not support the higher speeds and a shift was made to cost-effective short-wavelength (850nm) Vertical Cavity Surface Emitting Lasers (VCSELs). However, standard multimode fiber is not optimized for VCSELs, and as a result cannot support the necessary distances. By removing the impurities and carefully grading the index of refraction of the core of multimode fibers, laser optimized 50μm multimode fiber can achieve 10 Gbps Ethernet to 550 meters (see Figure 5).
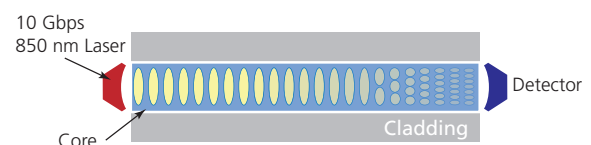
10 Gb/s reliable transmission, design flexibility
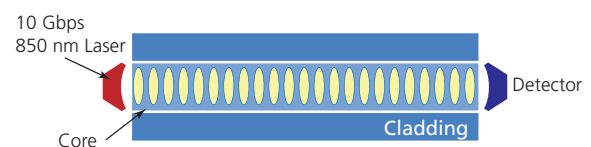
Laser Optimized MM fibers control DMD to support 10 Gb/s up to 300 or 550 meters with low cost 850 nm serial applications.

Figure 5. Standard Multimode Fiber vs. Laser Optimized Multimode Fiber

10 Gbps speeds are a reality today; maximizing your investment in your data center infrastructure cabling requires laser-optimized 50μm multimode fiber. This fiber type will support bandwidth requirements for the future and ensure reliability of your data center for many years to come. The cost difference between fiber types is minor when you consider total investment, and laser-optimized 50μm multimode fiber won't confine your infrastructure to length limitations. Because mixing and matching fiber types is not recommended, it makes sense to choose one fiber type that can reach all areas of your LAN and provide the most flexibility and future growth for your data center.

Copper Cable Management Systems

A good cable management system should save space by allowing you to maximize the number of cables and connections in a given footprint. It should also ensure reliability by protecting cable and connections and offer manageability through easy identification, access and reconfiguration. Because the use of a central patching location in a cross-connect scenario provides a logical and easy-to-manage infrastructure that helps manage growth without disrupting service, data center cable management systems must also easily and efficiently accommodate this scenario.

ADC's Ethernet Distribution Frame (EDF) forms a central patching location between active Ethernet network elements. By creating a centralized interface for Ethernet equipment, the EDF enhances data center manageability by enabling quick modifications and reconfigurations without service disruptions. With the EDF, permanent connections protect equipment cables from daily activity that can damage the cables. The EDF cross-connect also scales easily for adding new technologies, and its high-density interface maximizes active ports and conserves valuable floor space.

At the heart of the EDF is ADC's Glide Cable Management system, which consists of troughs that bolt to the side of the frames and provide integrated front, rear, horizontal, and vertical management, eliminating the need for horizontal cable managers that take up valuable rack space. The Glide Cable Management effectively doubles rack density for data center space savings, maintains reliability through built-in bend radius protection, and offers better manageability by organizing cables for easy reconfiguration and effectively storing cable slack.

Fiber Cable Management Systems

Fiber is a critical component of the data center, but it is also a delicate medium. Fiber cable management must protect fiber at all times for reliability while providing space savings and manageability. ADC's Next Generation Frame (NGF) product line meets these objectives while promoting unlimited growth.

Ideally used in a cross-connect scenario, ADC's Next Generation Frame is a fiber distribution frame that allows you to implement the maximum number of fibers in a given space. This high-density solution optimizes reliability and manageability through a balance of density, protection and functionality. Ample trough space reduces fiber congestion and potential damage while enabling growth. Complete bend radius protection reduces attenuation of the signal and maintains consistent, long-term fiber performance. Easy front and rear connector access, built-in jumper slack storage, and intelligent routing paths provide easy identification, tracing and maintenance.

Within the data center, it's critical that fiber jumpers not only be protected at the fiber distribution frame, but also within the pathways going to and from the fiber frame. ADC's FiberGuide® Management System physically separates, protects, and routes fiber while ensuring that a two-inch minimum bend radius is maintained throughout, even as more cables are added in the future. The system is extremely flexible, making data center fiber routing simple and reducing installation time without sacrificing durability. The FiberGuide's covers protect fiber from accidental damage while enabling easy access for rerouting and reconfiguration. Whether it's for jumpers going from frame to frame in a high-density situation or jumpers to server cabinets, in any data center cross-connect scenario, the FiberGuide's covers can provide ample pathway space, fiber protection for reliability, and simplified manageability.

Deployment

The graphic below depicts a sample data center using ADC's comprehensive line of data center-grade infrastructure products.
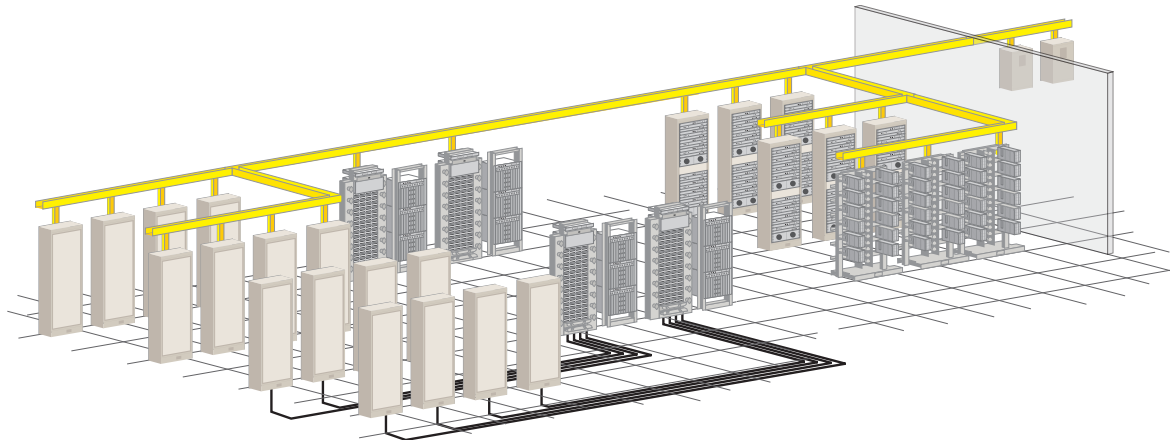
Fiber Distribution Boxes - Wall Mount

- WMG
- FL2000
- Building Entrance Terminals

Fiber Raceways
- FiberGuide
- FiberGuide, plenum
- RiserGuide

Fiber Distribution Frames
- Next Generation Frame (NGF)

Fiber Panels, Term, Splice, Storage - Race Mount

- FL2000
- Fiber Management Tray (FMT)
- FPL
- RMG

Fiber Cable - Riser and Plenum

- Singlemode
- Multimode 50 and 62.5um
- Laser-Optimized
- Armored

Copper Patch Panels and Blacks

- CopperTen Augmented Category 6
- Category 6

Copper/Fiber Rack Systems

- Glide Cable Management System

Copper Cable - Riser and Plenum

- CopperTen Augmented Category 6
- Category 6

Additional Considerations

Standards

The TIA-942 Telecommunications Infrastructure Standard for Data Centers was published in 2005 and specifies requirements and guidelines for data center infrastructures. The standard covers cabling distances, pathways, site selection, space, and layout, and is a valuable tool in designing your data center infrastructure.

TIA-942 specifies the following key functional areas in the data center:

- One or more entrance rooms – houses carrier equipment and the demarcation point
- A main distribution area (MDA) – houses the data center's main cross-connect
- One or more horizontal distribution areas (HDA) — houses horizontal cross-connects and is the distribution point for cabling to the equipment distribution areas

- A Zone Distribution Area (ZDA) – a structured cabling area for floor-standing equipment that cannot accept patch panels
- An Equipment Distribution Area (EDA) – houses equipment racks and cabinets in a hot aisle/cold aisle configuration to dissipate heat from electronics

To help you evaluate the required reliability of your data center, TIA-942 also provides a tier classification with specified availability and guidelines for equipment, power, cooling, and redundancy.

Cooling

Servers and equipment are getting smaller and more powerful to accommodate the need for high-density data center installations. However, this concentrates an enormous amount of heat into a smaller area. Adequate cooling equipment is a must, as well as the use of hot aisle/cold aisle configuration where equipment racks are arranged in alternating rows of hot and cold aisles. This practice, which has met wide industry acceptance,

allows cold air from the cold aisle to wash over the equipment where it is then expelled out the back into the hot aisle.

Power Requirements

Electricity is the lifeblood of a data center. A power interruption for even a fraction of a second is enough to cause a server failure. The measures you employ to prevent disruptions should be based on the level of reliability required. Common practices include:

• Two or more power feeds from the utility company

• Uninterrupted power supplies

• Multiple circuits to systems and equipment

• On-site generators

It's important to properly estimate your power requirements based on the devices currently in use in the data center, as well as the number of devices you anticipate needing in the future to accommodate growth. Power requirements for support equipment should also be included.

Avoid Costly Downtime and Prepare for the Future

Business can optimize their data centers by selecting data center infrastructure solutions that work together. By recognizing the value of the data center infrastructure and its components, you can ensure that employees and customers have access to the servers, storage systems, and networking devices they need to carry out daily business transactions and remain productive.

Avoiding costly downtime, preparing for the future, and lowering total cost of ownership with space savings, reliable performance, and effective manageability is the ultimate means to a thriving data center and overall successful business. *For more information on data center design, deployment and components visit the following Web sites:*

For information on...	See the following...
TIA-942 Standard	The TIA (www.tiaonline.org/standards)
General data center reliability information including power and cooling	The Uptime Institute (www.upsite.com)
Data center solutions	www.adc.com

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