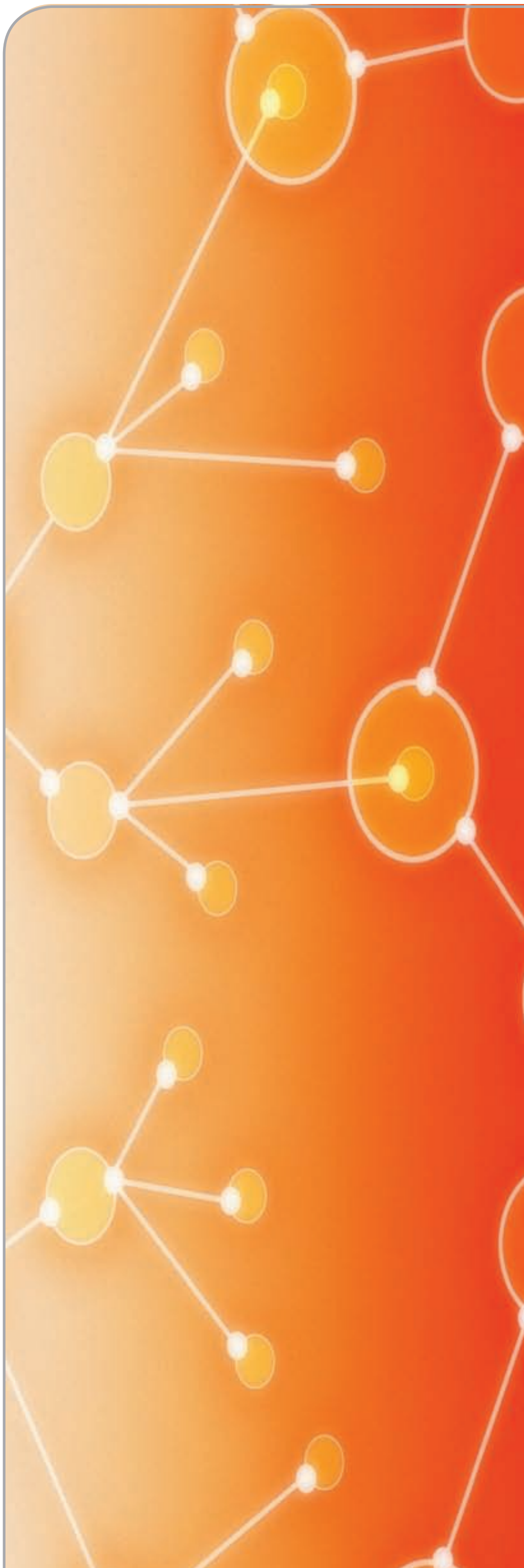

WHITE PAPER

Designing an Optimized Data Center

Designing an

Optimized Data Center

The data center is a key resource. Many organizations simply shut down when employees and customers are unable to access the servers, storage systems, and networking devices that reside there. Literally, millions of dollars can be lost in a single hour of down time for some businesses, such as large banks, airlines, package shippers, and online brokerages. Given these consequences, reliability is a key data center attribute. Another is flexibility. Tomorrow's requirements may not be the same as today's. Advances in technology, organizational restructuring, and even changes to the broader society may impose new demands.

Designing and building a data center to meet these requirements is not a simple or insignificant task. Armed with information, however, the task may become more manageable. That is the purpose of this white paper. While far from a complete discussion on this complex subject, it offers insights into key data center design issues and points you to additional sources of information. Topics covered include:

- Space and layout
- Cable management
- Power
- Cooling

Figure 1. Equipment and Cable Racks

Space and Layout

Data center real estate is valuable, so designers need to ensure that there is a sufficient amount of it and that it is wisely used. This will include:

- Ensuring that future growth is included in the assessment of how much space the data center requires. The space initially needed may be inadequate in the future.
- Ensuring that the layout includes ample areas of flexible white space, empty spaces within the center that can be easily reallocated to a particular function, such as a new equipment area.
- Ensuring that there is room to expand the data center if it outgrows its current confines. This is typically done by ensuring that the space that surrounds the data center can be easily and inexpensively annexed.

Layout

In a well-designed data center, functional areas are laid out in a way that ensures that

- Space can be reallocated easily to respond to changing requirements, particularly growth
- Cable can be easily managed so that cable runs do not exceed recommended distances and changes are not unnecessarily difficult

Layout Help: TIA-942

TIA-942, Telecommunications Infrastructure Standard for Data Centers, a standard that has yet to be released as of this writing (May, 2004), offers guidance on data center layout. According to the standard, a data center should include the following key functional areas:

- One or more entrance rooms
- A main distribution area (MDA)
- One or more horizontal distribution areas (HDA)
- A zone distribution area (ZDA)
- An equipment distribution area

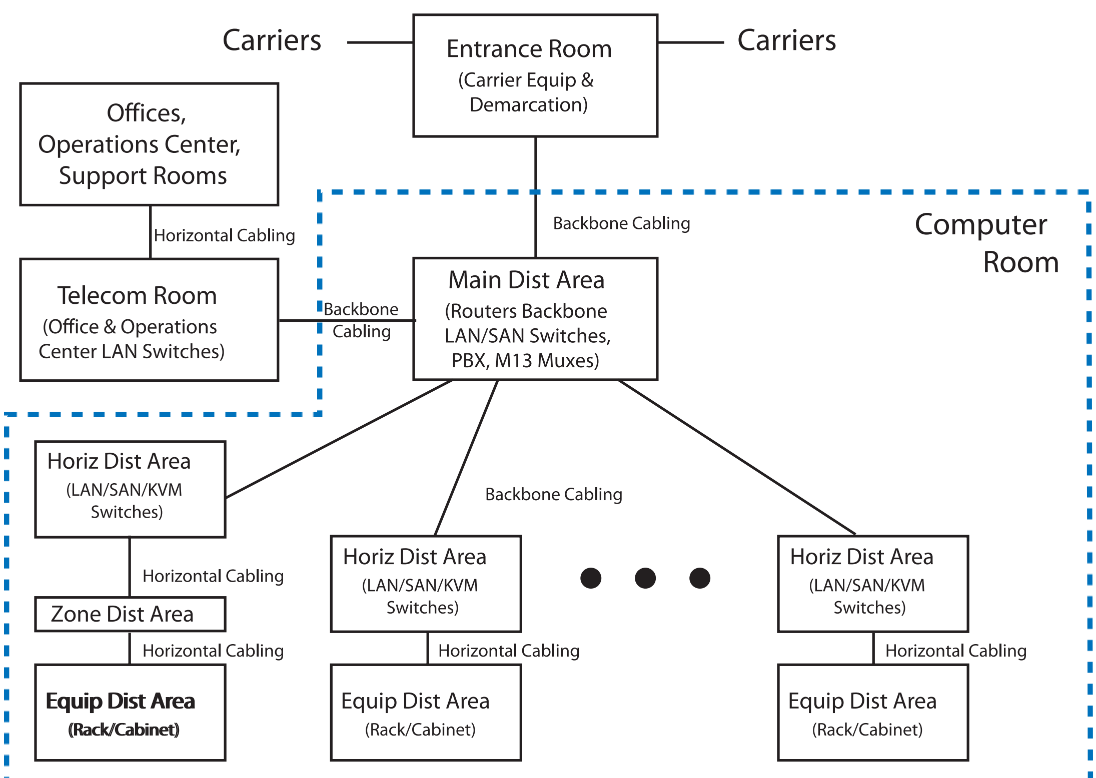

Figure 2. TIA-942 Compliant Data Center

Space and Layout

Entrance Room

The entrance room houses carrier equipment and the demarcation point. It may be inside the computer room, but the standard recommends a separate room for security reasons. If it's housed in the computer room, it should be consolidated within the main distribution area.

Main Distribution Area

The MDA houses the main cross-connect, the central distribution point for the data center's structured cabling system. This area should be centrally located to prevent exceeding recommended cabling distances and may include a horizontal cross-connect for an adjacent equipment distribution area. The standard specifies separate racks for fiber, UTP, and coaxial cable.

Horizontal Distribution Area

The HDA is the location of the horizontal cross-connects, the distribution point for cabling to equipment distribution areas. There can be one or more HDAs, depending on the size of the data center and cabling requirements. A guideline for a single HDA is a maximum of 2000 4-pair UTP or coaxial terminations. Like the MDA, the standard specifies separate racks for fiber, UTP, and coaxial cable.

Zone Distribution Area

This is the structured cabling area for floor-standing equipment that cannot accept patch panels. Examples include some mainframes and servers.

Equipment Distribution Area

This is the location of equipment cabinets and racks. The standard specifies that cabinets and racks be arranged in a "hot aisle/cold aisle" configuration to effectively dissipate heat from electronics.
See page 11 for a discussion on cooling.

Figure 3. Data Center with Flexible White Space

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Cable Management

The key to cable management in the optimized data center is understanding that the cabling system is permanent and generic. It's like the electrical system, a highly reliable and flexible utility that you can plug any new application into. When it's designed with this vision in mind, additions and changes aren't difficult or disruptive.

Key Principles

Highly reliable and resilient cabling systems adhere to the following principles:

- Common rack frames are used throughout the main distribution and horizontal distribution areas to simplify rack assembly and provide unified cable management.
- Common and ample vertical and horizontal cable management is installed both within and between rack frames to ensure effective cable management and provide for orderly growth.
- Ample overhead and underfloor cable pathways are installed—again, to ensure effective cable management and provide for orderly growth.
- UTP and coaxial cable are separated from fiber in horizontal pathways to avoid crushing fiber—electrical cables in cable trays and and fiber in troughs mounted on trays.
- Fiber is routed using a trough pathway system to protect it from damage.

Figure 4. Elements of Cable Management

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Cable Management

Figure 5. Cable Racks

Racks and Cabinets

Cable management begins with racks and cabinets, which should provide ample vertical and horizontal cable management. Proper management not only keeps cabling organized, it also helps keep equipment cool by removing obstacles to air movement. These cable management features should protect the cable, ensure that bend radius limits are not exceeded, and manage cable slack efficiently (Figure 5).

It's worth doing a little math to ensure that the rack or cabinet provides adequate cable management capacity. The formula for Category 6 UTP is shown below. The last calculation (multiplying by 1.30) is done to ensure that the cable management system is no more than 70 percent full.

Formula Cables x 0.0625 square inches (cable diameter) x 1.30 = Cable Management Requirement.

Example 350 cables x .0.0625 x 1.30 = 28.44 square inches (minimum cable management of 6" x 6" or 4" x 8)

Cable Routing Systems

A key to optimized cable routing is ample overhead and under floor cable pathways. Use the under floor pathways for permanent cabling and the overhead for temporary cabling. Separate fiber from UTP and coaxial to ensure that the weight of other cables doesn't crush the more fragile fiber.

Ideal Rack and Cable Routing System

What is an ideal rack and cable routing system? Figure 6 is an illustration of ADC KRONE's vision. Here are some key features:

1. The FiberGuide® assembly is mounted to the overhead cable racking and protects fiber optic cabling.
2. Express Exits™ units are mounted where they are needed, allowing flexible expansion or turn-up of new network elements.
3. Upper and lower cable troughs are used for patch cords and jumpers, and an overhead cable rack is used for connection to equipment located throughout the data center.
4. Eight-inch Glide Cable Manager with integrated horizontal cable management organizes cables and aids in accurate cable routing and tracing
5. Racks are equipped with 3.5-inch upper troughs (2 RUs) and 7-inch lower troughs (4RUs), providing adequate space for cable routing.
6. Eight-inch vertical cable managers are shown. Six-, ten-, and 12-inch cable managers are also options, to best meet the specific requirements of the data center installation and applications.

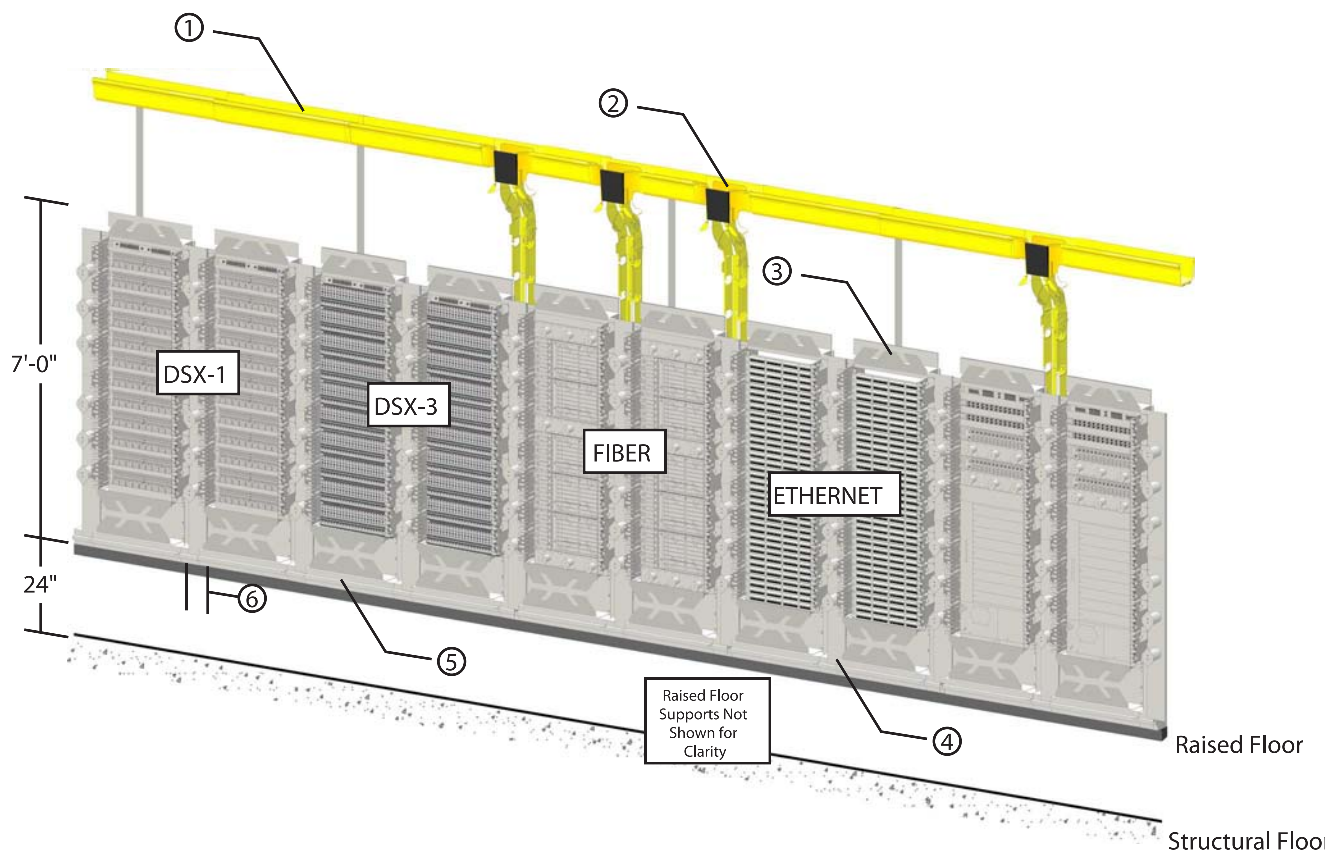

Figure 6. Fully-Populated, Fully-Integrated Lineup

Introduction to Connection Methods

The industry recognizes three methods of connecting equipment in the data center: direct connect, interconnect, and cross-connect. Only one of these, however – cross-connect – adheres to the vision of the cabling system as a highly-reliable, flexible and permanent utility.

Direct Connect

In the data center, direct connection (Figure 7) is not a wise option because when changes occur operators are forced to locate cables and carefully pull them to a new location, an intrusive, expensive, unreliable, and time-consuming effort. Data centers that comply with TIA-942 do not directly connect equipment.

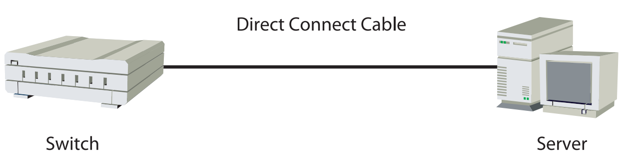

Figure 7. Direct Connect

Interconnect

When change occurs with an interconnect connection (Figure 8), operators reroute end system cables to reroute the circuit. This is far more efficient than the direct connect method, but not as easy or reliable as the cross-connect method.

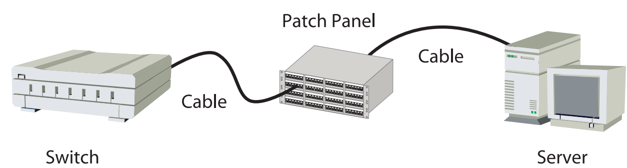

Figure 8. Interconnect

Cross-Connect

With a centralized cross-connect patching system, achieving the dual requirements of lower costs and highly reliable service is possible. In this simplified architecture, all network elements have permanent equipment cable connections that are terminated once and never handled again. Technicians isolate elements, connect new elements, route around problems, and perform maintenance and other functions using semi-permanent patch cord connections on the front of a cross-connect system, such as the ADC KRONE Ethernet Distribution Frame shown in Figure 9. Here are a few key advantages provided by a well-designed cross-connect system:

- Lower operating costs: Compared to the other approaches, cross-connect greatly reduces the time it takes for adding cards, moving circuits, upgrading software, and performing maintenance.
- Improved reliability and availability: Permanent connections protect equipment cables from daily activity that can damage them. Moves, adds, and changes are effected on the patching field instead of on the backplanes of sensitive routing and switching equipment, enabling changes in the network without disrupting service. With the ability to isolate network segments for troubleshooting and reroute circuits through simple patching, data center staff gains time for making proper repairs during regular hours instead of during night or weekend shifts.
- Competitive advantage: A cross-connect system enables rapid changes to the network. Turning-up new service is accomplished by plugging in a patch cord instead of the labor-intensive task of making multiple hard-wired cable connections. As a result, cards are added to the network in minutes instead of hours, decreasing time to revenue and providing a competitive edge—faster service availability.

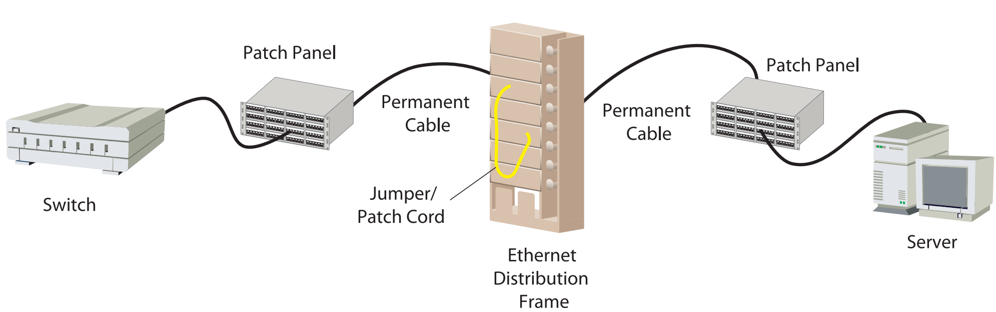

Figure 9. Cross-Connect

Fiber Optics: An Introduction

The benefits of fiber optic cabling are well known. It's indispensable for bandwidth hungry applications, environments where high levels of EMI are likely, and cable runs that exceed the recommended distances for copper. To get the most from your investment in this valuable resource, however, it needs to be managed properly.

Plan for Growth

Data center personnel often underestimate their requirements for fiber optic cabling, believing that the first few strands are the end of it. That's seldom true. The best practice is to assume that your fiber requirements will grow and to plan to handle that growth efficiently.

Handling Considerations

Fiber is far from the delicate medium imagined by some. It can be broken, however, if it is bent beyond the bend diameter specified by the manufacturer. To prevent this, effective fiber management systems should provide:

- Routing paths that reduce the twisting of fibers
- Access to the cable so that it can be installed or removed without inducing excessive bends in adjacent fiber
- Physical protection of the fiber from accidental damage by technicians and equipment

Splicing vs. Field Connectorization

There are two methods for connecting strands of fiber, splicing and field connectorization. The best choice depends on the application. For short runs of multimode fiber, using field connectorization is a good choice. It is also an alternative for temporary connections. Otherwise, splicing is the preferred method for the following reasons:

- **Lower signal loss:** Field-terminated connectors – under the best circumstances – offer 0.25 dB signal loss. Loss from fusion splicing is typically 0.01dB.
- **More predictable results:** Anecdotal evidence indicates that as many as 50 percent of field-installed connectors fail when done by green technicians.
- **Speed:** Trained technicians can splice two strands of fiber together in as little as 30 seconds or six minutes for two 12-strand fiber bundles.

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Power

Requirements

Electricity is the life blood of a data center. A power interruption of even a fraction of a second is enough to cause a server failure. To meet demanding availability requirements, data centers often go to great lengths to ensure a reliable power supply. Common practices include:

- Two or more power feeds from the utility company
- Uninterrupted power supplies (UPS)
- Multiple circuits to computing and communications systems and to cooling equipment
- On-site generators

The measures you employ to prevent disruptions will depend on the level of reliability required and, of course, the costs. To help you sort through the tradeoffs, the Uptime Institute, an organization concerned with improving data center performance, has developed a method of classifying data centers into four tiers, with Tier I providing the least reliability and Tier IV the most. Use this system, which is described briefly in the following table, to help you sort through the tradeoffs.

Estimating Power Requirements

Estimating the data center power needs involves the following steps:

1. Determine the electrical requirements for the servers and communication devices that are in use now. You can get this information from the device's nameplate. While the nameplate rating isn't a perfect measurement, it is the best data available to you.
2. Estimate the number of devices required to accommodate future growth and assume that these new devices will require the average power draw of your current equipment. Be sure that this estimate includes equipment that will supply the level of redundancy required by your data center. While estimating future needs is a difficult and imprecise exercise, it will provide better guidance on future needs than any other method.
3. Estimate the requirements for support equipment, such as power supplies, conditioning electronics, backup generation, HVAC equipment, lighting, etc. Again, be sure that this estimate includes redundant facilities where required.
4. Estimate the power requirements for this support equipment.
5. Total the power requirements from this list.

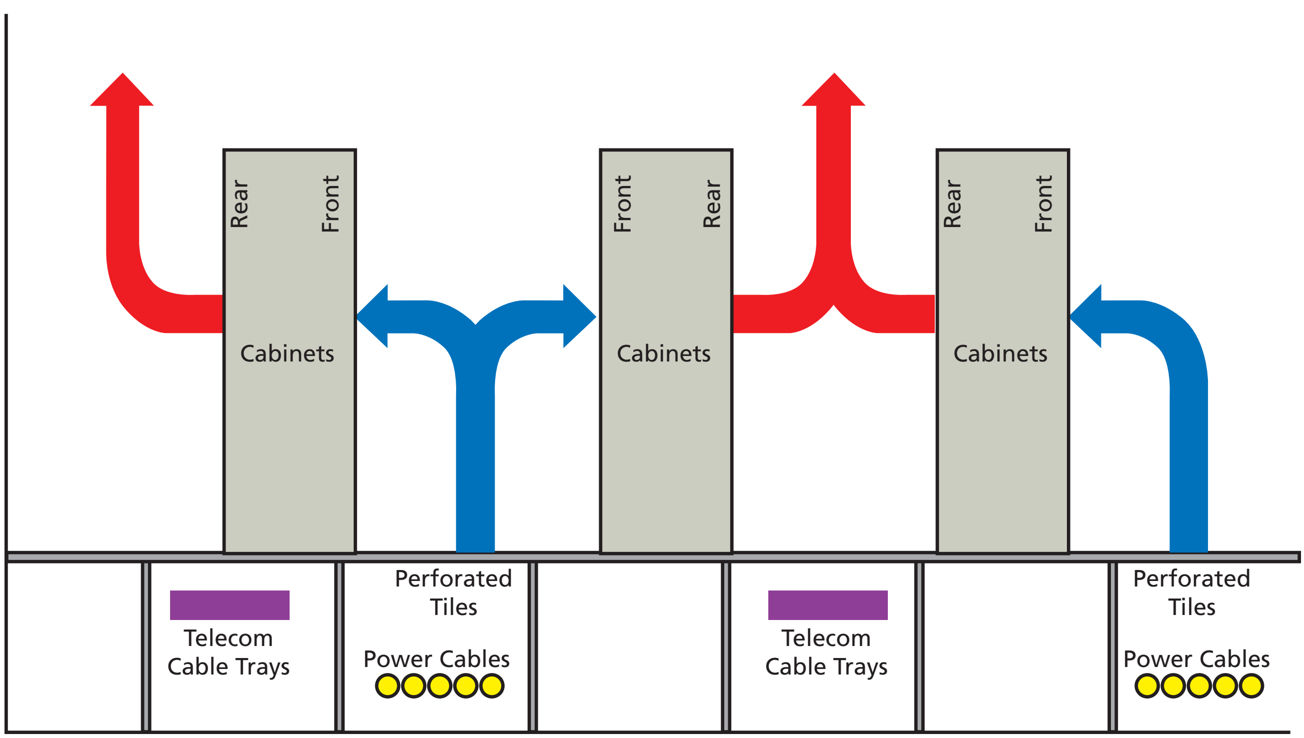
Tier	Description	Availability
I	Tier I centers risk disruptions from planned and unplanned events. If they have a UPS or an engine generator, they are single-module systems with many single points of failure. Maintenance will require a shutdown and spontaneous failures will cause data center disruption.	99.671%
II	Tier II centers are slightly less susceptible to disruptions than Tier I centers because they have redundant components. However, they have a single-threaded distribution path, which means that maintenance on the critical power path and other infrastructure parts will require a shutdown.	99.741%
III	Tier III centers can perform planned maintenance work without disruption. Sufficient capacity and distribution are available to simultaneously carry the load on one path while performing maintenance on the other. Unplanned activities, such as errors in operation or spontaneous failures of components will still cause disruption.	99.982%
IV	Tier IV centers can perform any planned activity without disruption to the critical load and sustain at least one worst-case unplanned failure with no critical load impact. This requires simultaneously active distribution paths. Electrically, this means two separate UPS systems in which each system has N+1 redundancy. Tier IV requires all computer hardware to have dual power inputs. Because of fire and electrical safety codes, there will still be downtime exposure due to fire alarms or people initiating an Emergency Power Off (EPO).	99.995%

Cooling

Servers, storage area devices, and communications equipment are getting smaller and more powerful. The tendency is to use this reduced footprint to cram more gear into a smaller space, thus concentrating an incredible amount of heat. Dealing with this heat is a significant challenge. Adequate cooling equipment, though a start, is only part of the solution. Air flow is also critically important. To encourage air flow, the industry has adopted a practice known as "hot aisle/cold aisle." In a hot aisle/cold aisle configuration, equipment racks are arranged in alternating rows of hot and cold aisles. In the cold aisle, equipment racks are arranged face to face. In the hot aisle, they are back to back. Perforated tiles in the raised floor of the cold aisles allow cold air to be drawn into the face of the equipment. This cold air washes over the equipment and is expelled out the back into the hot aisle. In the hot aisle, of course, there are no perforated tiles, which keep the hot air from mingling with the cold. For the best results with this method, aisles should be two tiles wide, enabling the use of perforated tiles in both rows if required.

This practice has met with wide industry acceptance. In fact, it's part of the TIA-942 recommendation. Unfortunately, it's not a perfect system. While it's common for equipment to exhaust heat out the back, it's not a universal practice. Some equipment draws cold air in from the bottom and discharges the heated air out the top or sides. Some brings in cold air from the sides and exhausts hot air out the top. If additional steps are required, other things to try include:

- Spreading equipment out over unused portions of the raised floor. Obviously, this is an alternative only if unused space is available.
- Increasing the height of the raised floor. Doubling floor height has been shown to increase air flow as much as 50%.
- Using open racks instead of cabinets. If security concerns or the depth of servers makes using racks impossible, cabinets with mesh fronts and backs are alternatives.
- Increasing air flow under the floor by blocking all unnecessary air escapes.
- Replacing existing perforated tiles with ones with larger openings. Most tiles come with 25% openings, but some provide openings of 40 to 60%.



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Conclusion

The optimized data center is a well-designed system, each of its component parts working together to ensure reliable access to the center's resources while providing the flexibility needed to meet unknown future requirements. Neglecting any aspect of the design is likely to leave the data center vulnerable to very costly failure or to early obsolescence. This white paper has addressed several key design considerations and offered the following recommendations:

- **Space:** Ensure that there is enough of it and allocated flexibly to meet both current and future needs.
- **Cable Management:** Treat the cabling system as a permanent and generic utility, a highly reliable and flexible resource that can easily accommodate any new application.
- **Power:** It's the life blood of the data center. Build the level of redundancy needed to meet your data center's access requirements.
- **Cooling:** Cooling equipment isn't your only concern in this area. Air flow strategies also play a significant role.

For More Information

See the following web sites for more information on data center issues.

For information on...	See the following...
TIA-942	The TIA website (www.tiaonline.org/standards)
General data center reliability issues, including power and cooling	The Uptime Institute (www.upsite.com)
ADC KRONE IP Infrastructure Solution	www.adckrone.com/in
ADC KRONE Datacenter solutions	www.adckrone.com/in

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