Planning Effective Power and Data Cable Management in IT Racks

White Paper 203

Revision 0

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Executive summary

Poor rack cable management has proven to many data center operators to be a source of downtime and frustration during moves, adds and changes. It can also lead to data transmission errors, safety hazards, poor cooling efficiency, and a negative overall look and feel of the data center. This paper discuses the benefits of effective rack cable management, provides guidance for cable management within IT racks including high density and networking IT racks, which will improve cable traceability and troubleshooting time while reducing the risk of human error.

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Introduction

Trends such as high density servers, converged infrastructure, and high availability result in an abundance of power and data cables within IT racks. A comprehensive strategy for managing power and data cables within IT racks is critical for the uptime, safety, and cooling efficiency of data centers. Advancements in IT rack designs have improved power and data cable management. For more information on the selection of an IT rack, see White Paper 201, *How to choose an IT rack*.

Effective rack power and data cable management leads to a number of IT infrastructure benefits including:

- **Enhanced availability** through reduced downtime. A system operator or employee can be easily confused by a mess of cables, which often results in human error. Human error is widely regarded as the leading cause of data center downtime based on a study by The Uptime Institute[1]. Effective cable management can help system operators to manage cables and IT devices easily, so as to reduce human error.
- **Improved system performance** through reduced crosstalk and interference between power and data cables. Power and data cables in close proximity to each other can create electromagnetic interference (EMI), which can result in erratic or error-prone data transfer in network cables. Cable management tends to separate power and data cables within the racks, which can help reduce the risk of interference.
- **Improved maintenance and serviceability** by allowing easier and safer access to individual components.
- **Increased cooling efficiency** by allowing hot exhaust air to escape out the back of the rack. Cable management keeps cables organized and out of critical airflow paths.
- **Improved scalability** by simplifying moves, adds, and changes. Cable management can make it easier to integrate additional racks and components in the future as the data center grows.

This paper provides guidance on power and data cable management that will improve physical appearance, cable traceability, airflow, cooling efficiency, and troubleshooting time while reducing the risk of human error. Following the steps outlined below can help you achieve a clean and well organized data center:

1. Plan
2. Determine the routes for power and data cables
3. Identify cables
4. Route and retain cables
5. Secure cables and connectors
6. Avoid thermal issues
7. Document and maintain organization

Step 1: Plan

Planning is the first step for power and data cable management in IT racks, and when done properly, it facilitates all of the steps below. Planning plays a critical role in any successful cable management project. If this is your first structured cabling project, we recommend that you hire a professional cabling contractor like Schneider Electric to complete the entire project. **Table 1** shows an example statement of work (SOW) for cable management. A

[1] A study by The Uptime Institute estimates that human error causes roughly 70% of the data center downtime. https://uptimeinstitute.com/.

cabling contractor should also test and certify all of the cables and document all related work. **Table 2** shows an example of statement of work for cable testing.

Table 1

Example of cable management SOW

Activities	Description
Management	CPCS* will provide cable management for the servers migrating over to the new CPCS racks.
	CPCS will dress cabling into neat and presentable bundles in all locations.
Installation	CPCS will install and manage all patch cords into the rack and organize them with a CPCS specific cable management system that allows for proper airflow in the rack.
Labels	CPCS will professionally label primary and secondary data cables, and primary and secondary power cables.
	CPCS will supply all professional labels and Velcro for cable management.
Logistics	CPCS will provide the knowledge and labor required for a well-organized and professionally maintained data center with minimal downtime.
	CPCS will utilize a fully tested cable management system.

*CPCS is the abbreviation of Schneider Electric Critical Power and Cooling Services[2].

Table 2

Example of cable testing SOW

Activities	Description
Advanced copper testing	CPCS will physically test each port from the Data Distribution Cables (DDC) to the switch for compliance to current standards, with customer approval.
	CPCS will use a network cabling certification tester, compliant to TIA/EIA TSB67 Level III specifications.
	The test reports will be available for viewing at the end of the project.
Advanced fiber testing	CPCS will test the Multimode Backbone at both 850 nanometers (nm) and 1300 nm in both directions of signal travel.
	CPCS will test the Single mode Backbone at both 1310 nm and 1550 nm in both directions of signal travel.
	CPCS will test the Horizontal Multimode WA optical fiber cables at the 850 nm wavelength in only one direction.
	The test reports will be available for viewing at the end of the project.
Basic copper testing	CPCS will perform a continuity port test and wire map of each port of the DDC cables.
Basic fiber testing	CPCS will test the polarity of each port.

A key output of the planning step is to determine the number of cables needed. This is done by calculating the number and type of connections per device and the total number of devices expected to be housed in the rack, based on the rack elevation drawings. For example, each 2U server could have four data cables, but on average there are two to three cables. Assuming there are (20) 2U servers housed in the rack, there will be a total of 40 to 60 cables in a relatively high density rack, or up to 80 cables in an ultra high density rack. Blade servers have fewer cables than 1 and 2U servers even though density may be substantially higher. Therefore, the amount of cabling in a rack varies widely based on the type of IT

[2] http://www.schneider-electric.com/ww/en/download/document/APC_TESS-6W9KFF_R1_EN_SRC?showAsIframe=true&xtmc=cable%20management%20statement&xtcr=1

equipment used. It is also important to know the growth plan of the IT equipment in the rack. This future cabling need should be included in the overall growth plan.

Step 2: Determine the routes for power and data cables

First, determine if the power and data cabling will enter from the top or bottom of the rack. Next, determine the routes for power cables, copper data cables, and fiber inside the cabinet.

Top or bottom entry

Once you know the number of cables to plan for, the next step is to determine the entry path of the cables into the IT rack. In other words, determine whether the cables will enter the IT rack through the roof or the floor. If entering from the top, the location of IT rack roof cutouts and their proximity to the vertical cable channels need to be considered. If entering from the bottom, consideration must be given to any obstructions in the base (such as large equipment mounted in the bottom) that can interfere with the cable entry path.

Routing cables into the bottom of the IT rack means the cables will most likely run under a raised floor. With this approach, the user loses visibility to the termination of the opposite end of the cable and this makes it more difficult to execute moves or changes later on. Furthermore, losing the ability to visually trace a cable increases the likelihood of disconnecting the wrong cable.

If cables come into the rack from the top, overhead cable management makes it easier to trace cables and manage moves. **Figure 1** shows an example of overhead cable management. Routing cables across the top of racks has the following distinct advantages over running them below the floor for both existing and new data centers:

- Improves overall cooling efficiency by keeping raised floor plenums clear where cabling would otherwise obstruct air flow (applies when a raised floor is used as a cold air plenum).
- Prevents cable breakage by avoiding harsh, damaging bends for cable bundles making sharp turns up through raised floors.
- Allows faster, easier, and consequently less expensive re-cabling when moving, adding, or changing configurations.

Figure 1

Example of overhead cable management

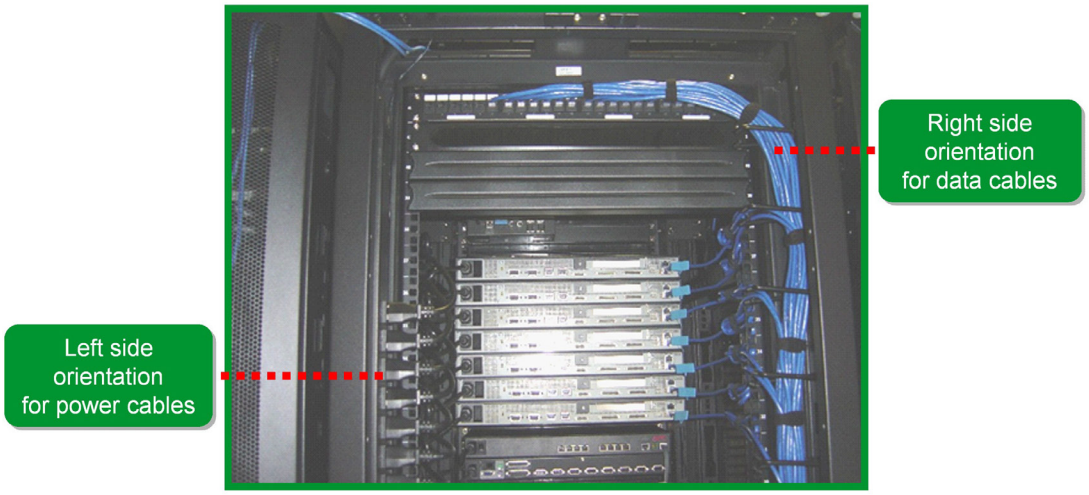
For more information on the advantages of overhead cabling, see White Paper 159, *How Overhead Cabling Saves Energy in Data Centers*.

Separate power and data cables

After determining the cable entry path, the next task is to separate power and data cables to prevent erratic or error-prone data transfers. To minimize the effects of EMI, power cables should be segregated from data cables as much as practical. Where power and data cables must cross, try to cross them perpendicular to each other to minimize EMI. It's a good practice to bundle data cables on one rear side of the IT rack and utilize the other rear side of the IT rack for distribution of power cables as shown in **Figure 2**. Another best practice is to use high quality cables like F/FTP CAT6A cables to minimize EMI.

Figure 2

Example of standard power cable and data cable layout



Furthermore, isolating data and power cables helps to reduce human error by lessening contact with power cables when handling data cables. Cables of different types are protected from jostling and movement of another type. Once data cabling is isolated to one side of the rack, it can be further organized based on its termination point within the rack, whether it is the primary or redundant connection, or other convenient characteristic dependant on the specific equipment layout. This additional level of organization can pay dividends when it comes time for equipment refresh or troubleshooting because cables are gathered in smaller bundles and grouped in a logical arrangement. Applying the same cable management standard across all racks facilitates IT rack management, and adopting cables with smaller diameter like AWG26 is also a good solution for space optimization in an IT rack. It is important to calculate the total amount of vertically managed cable to ensure enough space in the IT rack.

Separate copper data cables and fiber

There are two common types of data transmission media found in data centers: fiber optics and twisted-pair copper. Fiber optic cable is lighter than copper cable; but it is relatively delicate, must be handled carefully during installation, and may require extra components for protection. Damaged fiber optic cable poses no safety hazards but can result in degraded or interrupted performance. Ensure that copper and fiber runs are separated, because the weight of copper cables can damage the fiber.

When fiber cables are deployed in the IT rack, users may need to install fiber spools to take up the slack on each of the fiber runs. **Figure 3** shows an example of fiber routing. Given the requirement for spools and vertical cable channels, IT racks with significant amounts of fiber and copper cable will need to be wider or deeper than normal IT racks. Another best practice is to use bend-insensitive multimode fiber (BIMMF) to minimize the loss due to the bend radius.

Figure 3

Example of fiber routing using fiber spools

Step 3: Identify cables

Good cable identification and administration is an investment in infrastructure. The advantages of cable identification include easier and more accurate installation to reduce overall installation time, improving the routing of cables within the pathway, and reducing time required to identify and trace a cable when problems occur or when a move, add or change (MAC) is required. A little bit of time and expense upfront certainly saves a lot of money on the back-end. We recommend implementing both of the following best practices.

Use colored cables

Use of colored cables can simplify the management of equipment inside the rack. For example, the color orange could be used for network traffic, the color grey for the management system, the color green for redundant network cables, and the color red for cables supplying critical systems. Use of different color cables for similar equipment is also a good practice to simplify management. For example, different color for KVM vs. DRAC, production LAN vs. backup network, side A vs. side B power cords, etc.

Label cables

Labeling both ends of power and data cables is an integral part of the infrastructure installation and testing process, and is simply a good investment. The ANSI/TIA 606-B labeling standard has been approved since April 2012 and provides clear specifications for infrastructure labeling and identification for cables, racks, electrical and custom panels, patch panels, and punch blocks. According to the standard, automated infrastructure management (AIM) is required for cabling systems that span multiple campuses (i.e. Class 4 administration). **Figure 4** shows an example of AIM system.

Figure 4

Example of an Automated Infrastructure Management system

Step 4: Route and retain cables

Cables must be protected at points where they might rub or come in contact with sharp edges or heated areas. **Figure 5** shows an example of cable routing protection around hard edges using a cable management accessory known as a "waterfall". This kind of accessory provides a proper bend radius for cabling routed into/out of racks. It can attach in multiple locations including the rack roof holes, open frame rack sides, and vertical cable manager openings. Extra care must be used with power cables because damaged conductors could cause downtime and possibly create a safety hazard.

Figure 5

Example of cable routing protection
(Schneider Electric cable fall shown)

Nylon cable ties are normally used to bundle cables. **Figure 6** shows an improved flexible cable tie, which reduces waste during installation, and can be re-used. Other benefits include no sharp edges when cut and can be used to segregate cables in different bundles.

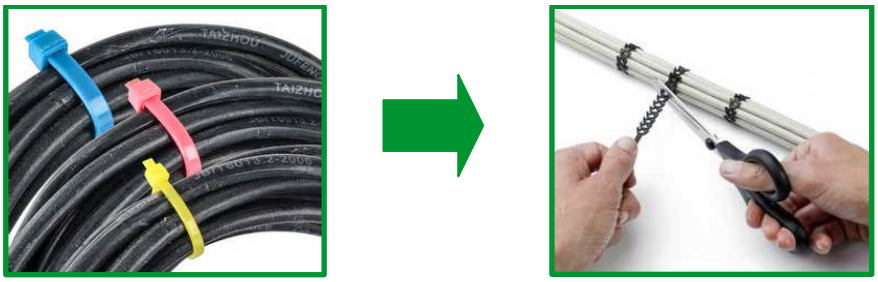


Figure 6

Flexible cable tie is used to replace nylon cable tie
(Schneider Electric Rapstrap shown)

Cable management arms can be used to control cable slack at the rear of each server. **Figure 7** shows an application of cable management arms. However, be aware when using cable management arms because they can interfere with rack PDUs and with the exhaust air path of servers by creating an "air dam" around the exhaust area of each server. This interference can lead to hot spots in the rack and may cause server fans and cooling units to work harder than they otherwise would.

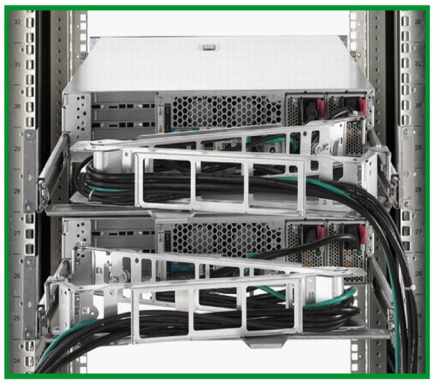


Figure 7

A sub-optimized IT rack with cable management arms

Step 5: Secure cables and connectors

Cables and connectors should be secured to prevent excessive movement and to provide strain relief of critical points. The normal practices are to ensure that cable connections are not stressed from any cable or chassis movement and to dress cables on management arms securely enough to prevent interference, movement, or pinched cables, yet not so tight as to cause binding to the arm.

Power cables and connectors should receive extra care during installation since loose cables or connectors can result in loss of power and unscheduled downtime. A loose power connector can create high contact resistance that can result in arcing and a fire hazard. Normal practices include using hardware such as retaining clips or tie strips to secure power connectors and cords to the product chassis and securing PDU power cables with removable ties to prevent accidental removal of cords from the system whenever possible.

Step 6: Avoid thermal issues

After cables are installed and labeled, the next step is to ensure the airflow path is clear of obstructions. If airflow is restricted, component temperatures can rise. Sustained higher temperatures can shorten devices' expected lifespan and cause unexpected failures resulting in unscheduled system downtime. For safe and reliable operation, ventilation slots and fans at the rear of IT devices must not be obstructed by cabling, cable management arms, or any other equipment. Therefore, for proper cooling of rack-mounted components, ensure that cabling does not impede the airflow to or from the rack-mounted servers.

Open space around cables permits hot exhaust air to recirculate to equipment air intakes resulting in inefficient cooling and even overheating. When passing cables from front to back in an IT rack, use airflow management blanking panels equipped with a flexible brush or shield that allow cables to pass through while preventing air leakage. For more information on the airflow management using blanking panels, see White Paper 44, *Improving Rack Cooling Performance Using Airflow Management™ Blanking Panels*.

Some networking equipment (e.g., routers and switches) draws cold air and expels hot air in a side-to-side fashion. This can present some unique challenges which must be addressed with special equipment. Fan assist modules pull cold air from the front and route it to the side. Special duct kits are also available to direct and contain air. For more information on the side air distribution application, see White Paper 50, *Cooling Options for Rack Equipment with Side-to-Side Airflow*.

Step 7: Document and maintain organization

There are two important things to do after installing the cables. One is to document what you have done. The other is to maintain organization.

Document

The most critical task in cable management is to document the complete infrastructure including diagrams, cable types, patching information, and cable counts. Keep this information easily accessible to data center personnel, and assign updates to one or more staff members. Ensure it is part of their job assignment to keep the documentation up-to-date. Furthermore, make sure the rack elevation document includes guidelines for installing new cables, cable management components, routing cables, and digital photographs as reference points to support the guiding principles. The cabling contractor should provide this documentation, so be sure that it is included in the statement of work and that it is delivered in a timely manner once the cabling is complete.

The current condition of the data center today sets a clear example of the expectations for tomorrow. IT service technicians are unlikely to, or may even be unable to follow best practices for organization within the IT rack if the equipment in the rack is already a nest of knotted cable with indiscernible paths or labels. In fact, it actually encourages more chaos. The most direct way to affect the level of organization in tomorrow's data center is to set a clear example today.

Change management

IT leaders must lead the way to organization by committing to constructing standard procedures and verifying that they are carried out. If leaders are not prepared to commit to practicing organization, it is easy for others to adopt poor practices as well. As new racks are deployed[3] expectations should be clearly documented with pictures in a repository that is accessible to all personnel that have cause to access the rack space. This documentation may include any of the aspects such as color of cable for particular uses, separation of data and power, and standardization of rack selection based on the equipment to be installed.

Discipline of administrators

When developing procedures, it is important to consider the steps involved in maintaining organization while performing the most common tasks. An example of a common task is to install a new server and provide network and power connections. In order to add network connections, a new cable must be routed to the server. If top-of-rack patching/switching is employed (i.e. home run cabling design), this task is greatly simplified since a run from the switch to the target rack has already been made. Still, the run from the top panel to the new server must make use of the appropriate vertical pathway. If the cable is bundled using zip ties, each tie must be cut and then replaced in order to maintain the level of organization. Shortcuts, such as simply adding new ties, are tempting because they have only marginal impact *this* time. However, if this shortcut is employed over and over again, the end result is a bundle of cable that is overrun with cable ties, each of which adds only a single cable to the previous bundle.

A more lasting solution is to use hook-and-loop style ties that can be opened and refastened as needed. This is more convenient for the user and therefore less likely to be sidestepped or ignored. The preferred method is to use ring-style cable managers, like the one shown in **Figure 8**, that do not require any opening or closing on the part of the installer and obviously stands out if circumvented.

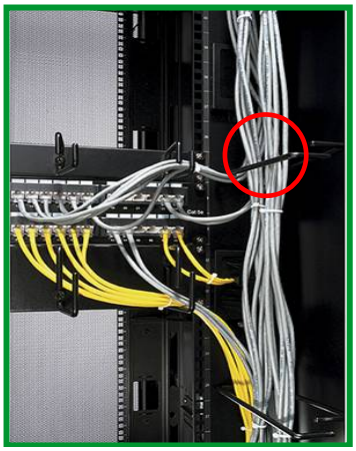


Figure 8

Vertical cable ring style cable manager

[3] See White Paper 201, *How to Choose an IT Rack*.

Making the decision to be organized at the initial deployment of a new rack is easy, but the real work comes in maintaining the level of organization in the future. Taking time to develop policies that not only provide organization but are also **obvious and easy** to maintain helps to ensure that the rigorous procedures are followed well into the future.

Cable management for high density IT racks

The most effective method for managing cables in high density environments is to implement patch panels or switches dedicated to cabling for a particular rack. These small switches or patch panels are typically located at the top or bottom of the IT rack, and are terminated back to the core switch or router feeding that section of the data center. The core switch is typically located in another IT rack and possibly another aisle.

This approach is effective because it separates the cabling inside the IT rack from the rest of the data center cable load. With top-of-rack patch panels (or switches), a large bundle of cables from individual servers traveling to a distant core switch can be reduced to a few or even a single run of structured trunk cable to the core switch. This reduces the physical size and number of cables, but also makes identifying and tracking runs much less complicated when troubleshooting is necessary. Additionally, it is possible to isolate and remove an entire rack of equipment and swap in a new rack quickly and repeatedly since they all have a common interface in a common location.

Top-of-rack switching further simplifies cable management by aggregating the server network connections to a simple set of uplink cables running back to the core switch. This eliminates many physical termination points that span a row or more within the data center, removes opportunities for human error at multiple touch points, and reduces troubleshooting time.

Patch cords of various lengths are connected between the patch panel/switch and the IT equipment. The cords should be managed horizontally from the panel and or the devices to the side of the IT rack and then managed vertically on the side of the IT rack (see **Figure 9**). Since most IT components are designed with network cable terminations on the rear, the cable routing resides in the rear of the IT rack.

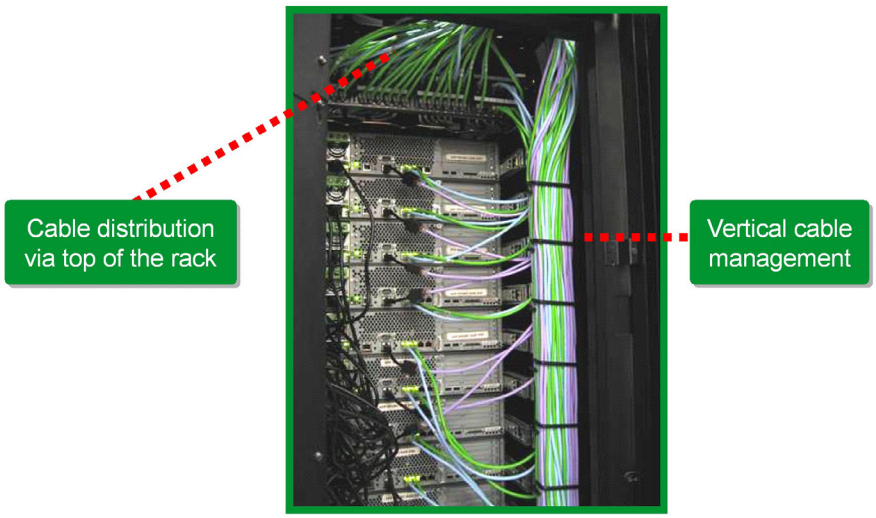


Figure 9

A well organized IT rack with vertical cable management and PDUs

Cable management for network racks

Network racks often house one or two switches that distribute cables to each of the IT racks housing the servers. These network racks are wider than normal and have unique requirements for cable management due to three main reasons:

- They need to accommodate much higher cable bundle quantities
- The majority of the patching connections typically occur at the front of the rack
- They need to support side-to-side airflow

Figure 10 shows a high density network rack application. The following lists some guidelines for network rack cable management:

- Use wide enclosures for high density cabling network racks to provide more cabling space.
- Mount power distribution in back of enclosure on rear cable channels.
- Cables can't be allowed to block the front of the switch. The switches within these IT racks have components that are removable from the front such as fan trays.
- Adopt IT racks which can accommodate a method to route cold air to the side of the switch[4].
- Use the setback side rails populated with horizontal cable managers to allow patching within the rack for top of rack switching.
- Use rack mount patch panels and cable managers along with vertically mounted cable managers to provide pathways for patch cords transcending from top of rack patch panels to bottom or rack switches.
- Use blanking panels to fill empty vertical spaces in the rack to maintain proper airflow. If any of the vertical space in the rack is not filled by components, the gaps between components cause a change in airflow through the rack and cross the component[5].

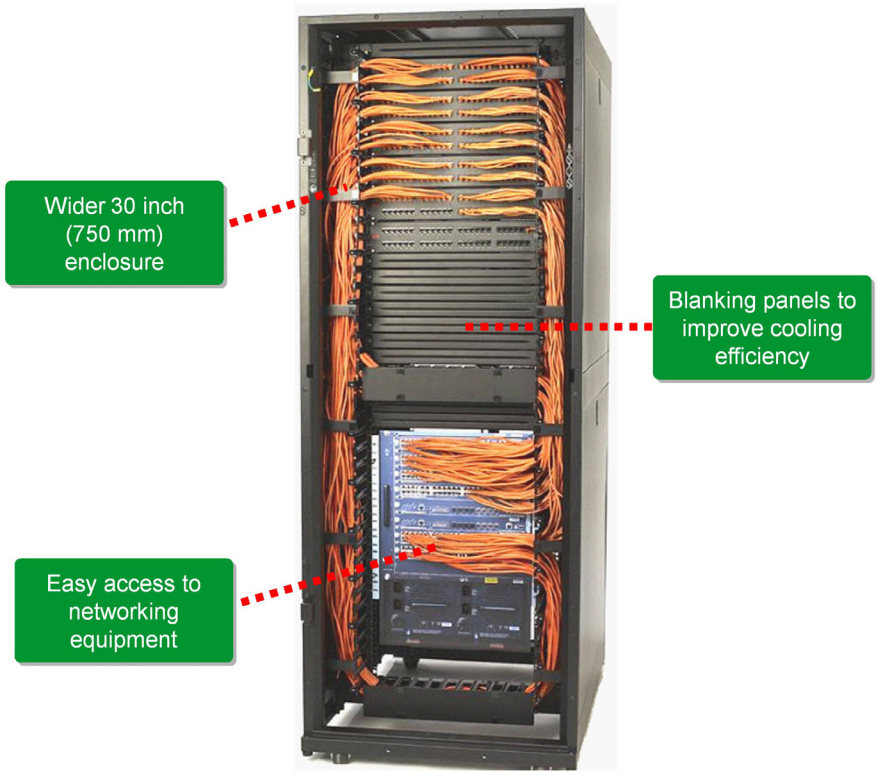


Figure 10

A high density networking application

[4] See White Paper 50, Cooling Solutions for Rack Equipment with Side to Side Airflow for more information.

[5] See White Paper 44, Improving Rack Cooling Performance Using Airflow Management™ Blanking Panels for more information.

Conclusion

Effective power and data cable management within IT racks makes a world of difference in tracing and replacing cables, easily removing hardware, increasing airflow, reducing trouble-shooting time, and reducing the risk of human error. By adopting good cabling guidelines, your hardware will run cooler and more efficiently and ensure the health and longevity of your cables. You also prevent premature hardware failures caused by heat retention.

About the authors

Paul Lin is a Senior Research Analyst at Schneider Electric's Data Center Science Center. He is responsible for data center design and operation research, and consults with clients on risk assessment and design practices to optimize the availability and efficiency of their data center environment. Before joining Schneider Electric, Paul worked as the R&D Project Leader in LG Electronics for several years. He is now designated as a "Data Center Certified Associate", an internationally recognized validation of the knowledge and skills required for a data center professional. He is also a registered HVAC professional engineer. Paul holds a master's degree in mechanical engineering from Jilin University with a background in HVAC and Thermodynamic Engineering.

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Resources

How to Choose an IT Rack
White Paper 201

How Overhead Cabling Saves Energy in Data Centers
White Paper 159

Cooling Solutions for Rack Equipment with Side-to-Side Airflow
White Paper 50

Improving Rack Cooling Performance Using Airflow Management™ Blanking Panels
White Paper 44

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