

Strategic Design of the Passive Network Infrastructure

The Proper Passive Infrastructure Improves Data Center Performance

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Executive Summary

The passive network infrastructure has been often viewed as an afterthought, as the simple nut-and-bolt building blocks onto which are hung the servers, switches, and other active network equipment as well as the cabling. But in today's data center, the passive infrastructure commands attention for its role in increasing operational efficiency, enabling server consolidation and virtualization, maintaining network uptime and application availability, and extending the life of the data center and lowering the cost of ownership. Simply put, the selection and deployment of the passive infrastructure can either aid or detract from efficient data center operation.

Introduction

The passive network infrastructure includes racks, cabinets, cable trays, and cable management hardware. Traditionally, these components are viewed as simple hardware, necessary but not really playing a significant role in helping a data center operate more efficiently or reliably. While there are lots of details to consider in comparing infrastructure products, the final selection has traditionally been more tactical than strategic.

As data centers evolve—particularly the deployment of rack-mount and blade servers in high-density configurations—selecting the right passive infrastructure components becomes an important decision that affects operations. That is, the passive infrastructure now plays a role in the active operations of the data center. The infrastructure protects and enhances the performance of the network cabling and electronics.

Layer Zero™ Infrastructure

The well-known OSI model of network layers begins with the Physical Layer as Layer 1, with the transport medium, or cabling, being the primary component. The model does not address the passive support infrastructure—nor do standards such as the IEEE's 802.3 for Ethernet or TIA's 568 for structured cabling. Given the growing importance of the active role the passive infrastructure plays in maintaining the efficiency and reliability of a data center, Legrand|Ortronics has created a new layer of the model to address the importance of the network infrastructure – Layer Zero™ – the Infrastructure Layer. The remainder of this paper looks at how both Layer Zero and Layer 1 infrastructure play an important role in

- Maximizing operational efficiencies
- Empowering virtualization
- Ensuring uptime and reliability
- Lowering the cost of ownership

Improving Operational Efficiencies

We can divide operational efficiencies into two categories: business agility and airflow management.

Business Agility

Business agility refers to the speed and flexibility with which the data center can be configured and reconfigured to support business needs. In terms of the passive infrastructure, business agility means how fast the cabling system can be installed and how easily MACs (moves, adds, changes) can be accomplished. Using ready-to-install preterminated cable assemblies offers the double advantage of faster installation and fewer performance headaches. Cable assemblies are typically factory tested to meet performance specifications such as TIA-568 and often offer performance “headroom.”

TIA-942 defines an optimal design methodology for the passive network infrastructure in a data center. Following the design practices outlined in this standard provides optimal flexibility in the cabling system to accommodate future growth and reconfiguration. Whether you are using overhead or underfloor cabling, TIA-942 offers solid advice on best practices that will enhance the ability to support the business functions that are supported by the data center.

Passive Airflow Management

The dramatic increase in power or processing densities in equipment racks requires new attention to cooling and to airflow management. The power consumed by a single rack of servers has evolved from a few kilowatts a few years ago to upwards of 50 kW. Trends responsible for this tremendous growth include both miniaturization of microelectronics and virtualization of applications. Miniaturization enables powerful servers in small packages. With each iteration packing more powerful servers into smaller areas—as in moving from 2U servers to 1U servers to blade servers—the power density increases significantly. While we will look at virtualization later in this paper, one consequence of virtualization is that servers work harder and have less idle time—and therefore generate more heat.

Cooling a single rack or cabinet is a relatively trivial matter. Cooling rows of cabinets, on the other hand, is complex because of the nonuniformity of airflow and temperatures within the space. This nonuniformity can create hot spots—

localized area where the temperature can exceed proper levels. High temperatures have three main consequences:

1. Servers can slow down until they cool down.
2. Servers can shut down if temperatures get too high.
3. Servers can experience shorter lives and reduced reliability from operating at elevated temperatures.

The preferred method of cooling in today's computer rooms is the aisle separation approach, as shown in Figure 1. In a typical configuration, cold air comes from beneath the raised floor up into the room through perforated floor tiles. This cold air is drawn through the equipment, where it picks up the heat generated by equipment, and exits the rear of the rack into the hot aisle. This hot air is then directed for recirculation through the CRAC units. Racks or cabinets are positioned to face each other, fronts on the cold aisle and backs on the hot aisle. It is important that the cold aisles remain cold and hot aisles hot: mixing air from the two should be avoided.

Conceptually, the aisle cooling works best when equipment draws air either in the front and exhausts it out the back or draws and exhausts air through the sides. Unfortunately, this is not always the case; some equipment draws air from the bottom and exhausts it through the sides or top.

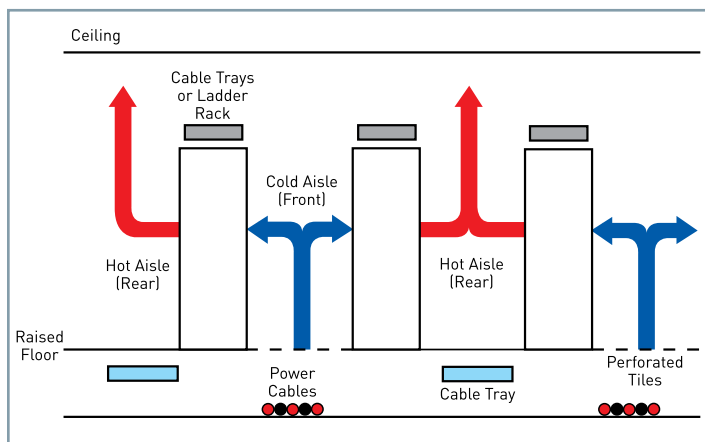


Figure 1: Cold- and hot-aisle cooling

The choice of racks or cabinets and the use of good cable management practices can also aid airflow. Spaces between cabinets should be blocked to prevent air from the hot and cold aisles from mixing. Such mixing can raise the temperature of the cold air at the equipment intake and thereby lower its effectiveness. Similarly, the use of blanking plates in unused equipment positions within the rack or cabinet maintains the hot aisle/cold aisle separation. This will allow more cold air to be directed into the equipment rather than be wastefully passed through empty areas. Some enclosures use top fans to

help exhaust the air out the top of the rack. Such fans can be a mixed blessing: they help move the air but are not as effective as passing the air directly into the hot aisle. Also, there are additional costs to operate and maintain such active cooling solutions.

In choosing an equipment rack, consider the ventilation configurations of the active equipment to be stored in the rack. If all the equipment uses front-to-back airflow, your chore is easier and your range of cable-management choices wider. If the equipment is side venting, make sure the rack can accommodate this. Racks such as the Mighty Mo® 10 from Legrand|Ortronics combine baffles and perforations to direct airflow from side-ventilated equipment from the cold aisle to the hot aisle. The perforations allow ventilated air to be exhausted, while the baffles ensure the proper flow of air from cold aisle to hot aisle, even with side ventilation. In effect, the combination of baffles and perforations allow side-ventilated equipment to act like rear-ventilated equipment as far as cooling is concerned. Plus, the system is passive—it does not require the additional 15 to 20 W of power that each exhaust fan would consume. This makes for a more energy-efficient data center, reducing overall power consumption and therefore energy costs.

Figure 2 shows the purpose of the baffle both in separating the hot and cold aisles and in helping control airflow through equipment (particularly side-vented boxes). Cold air is directed by the baffle into the rack, where it passes through the equipment and exits into the hot aisle. This arrangement has two main benefits:

1. It directs the cold air into the rack and equipment, preventing it from bypassing the rack and entering the hot aisle.
2. It prevents the hot air exhausted from equipment from mixing with the cold air used to cool the next rack.

Consider Figure 2 without the baffles. Warm exhaust air from Rack 1 could mix with the cool air entering Rack 2. In effect, the cooling efficiency would be reduced. In turn, the air exiting Rack 2 would be warmer than the exhaust air from Rack 1. So Rack 3 would be cooled by even warmer air. Without the controlled airflow offered by the rack's baffles, there is a cascading effect of higher intake temperatures and higher exhaust temperatures.

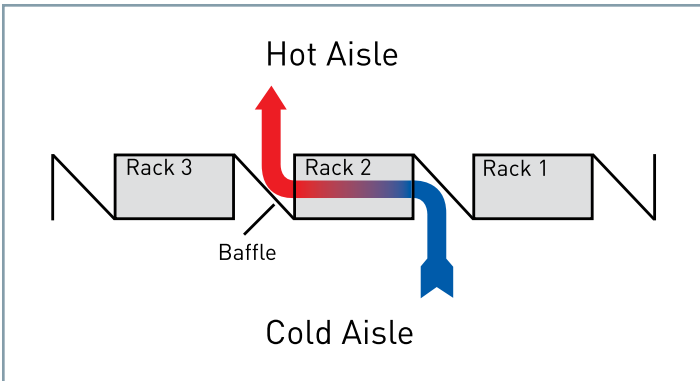


Figure 2. Baffles help segregate the hot and cold aisles, prevent mixing of hot and cold air, and increase the uniformity of cooling to each rack.

Legrand|Ortronics did thermal testing of multiple rack setups with and without the baffles. The tests used racks mounted with Cisco Catalyst 6509 switches. The study analyzed the thermal patterns that resulted.

Figure 3 shows the results of testing without airflow management. Exhaust air temperatures were much higher exiting the last rack. The significant differences in temperatures reflect the detrimental influences of upstream equipment.

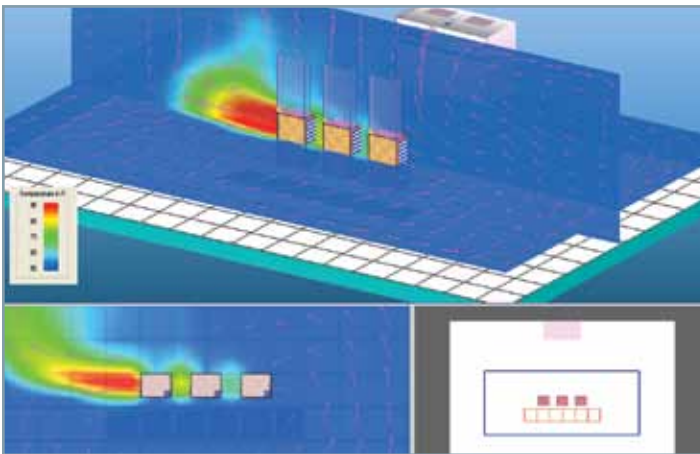


Figure 3. Thermal gradients without airflow management

Figure 4 shows that passive airflow management evens temperature gradients in the room. The exhaust of each server is redirected into the hot aisle, and each server's intake can only bring in air from the cold aisle. This means that each server is bringing in cool air from the cold aisle and the temperature in the hot aisle isn't raised as much as in the case of Figure 3 with passive management. Thus the room's CRAC unit no longer needs to work as hard to maintain the proper cold aisle or ambient temperature in the room.

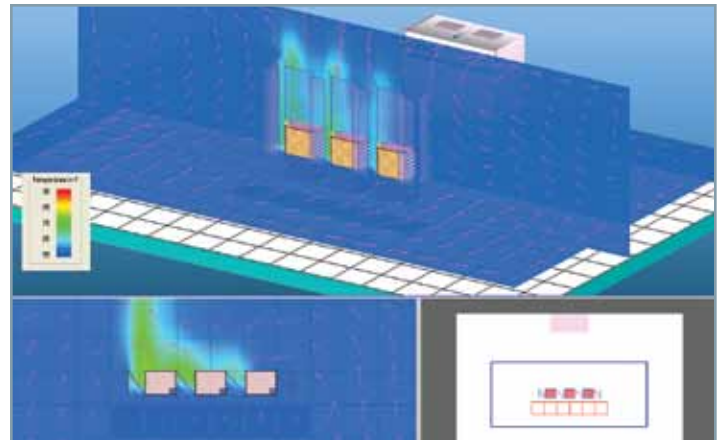


Figure 4. Thermal gradients with airflow management

Passive Airflow Management Saves Money

The practical consequences of passive airflow management are significant. Without passive airflow management, the cold-aisle temperature would need to be 50°F to keep the exhaust temperatures from Rack 3 at 85°F or below. Passive airflow management allows the cold-aisle temperature to be raised to 65°F, a 15°F increase in temperature, and still maintain an 85°F exhaust temperature for all three racks. Thus, the load on the room's CRAC is reduced, as is energy consumption.

Sun Microsystems has calculated that for every 1°F the data center's ambient temperature can be raised there is a resulting 4% reduction in energy costs. In the examples illustrated in Figures 3 and 4 the passive airflow management allowed a 60% reduction in energy costs to cool each network switch rack.

Airflow Management and Cables

Maintaining airflow is crucial to proper cooling. Underfloor cables should be routed to ensure cold air is delivered into the appropriate areas of the room. Cables should not block the perforated tiles in the cold aisle. Additionally, the underfloor plenum should not become filled enough to obstruct airflow.

Newer reduced-diameter UTP and fiber-optic cables improve airflow by taking up less space. For example, Berk-Tek, a Nexans company, has introduced a reduced-diameter version of its 10G UTP cable—with a 15% reduction of the O.D. from the maximum allowed by standards. Another example is Berk-Tek's compact MDP fiber optic cable. A 48-fiber MDP cable is less than half the size of a 48-fiber stacked ribbon cable. With high-port-count equipment requiring large cable bundles, these reductions add up to significant space savings.

Enabling Virtualization

Virtualization allows superior utilization of servers. A single server can be virtualized to run multiple operating systems and applications, each in its own virtual space and appearing as a stand-alone unit. With virtualization, one server can replace multiple unvirtualized servers. The advantage of reduced hardware requirements and the corresponding lowering of energy costs has made virtualization a key trend in today's computer room.

Virtualization does place greater demands on input/output connections (I/O). "Virtual environments require powerful mobility throughout the data center fabric—application performance depending much more on bandwidth and I/O."¹ I/O speeds are rapidly moving to 10 Gb/s as the minimum access speed for I/O so that each virtual server has access to high-speed I/O without bottleneck contentions from other virtual servers.

According to an Intel forecast shown in Figure 5, the trend for 10 Gigabit connections is expected to move away from fiber and toward copper. The predominant attachment method will be through the cabling network, although direct attachment will also grow. Virtualization is also bringing a consolidation of attachment protocols to allow various functions to run over Ethernet. A major example of this is Fibre Channel over Ethernet (FCoE), which allows Fibre Channel protocols within an Ethernet environment.

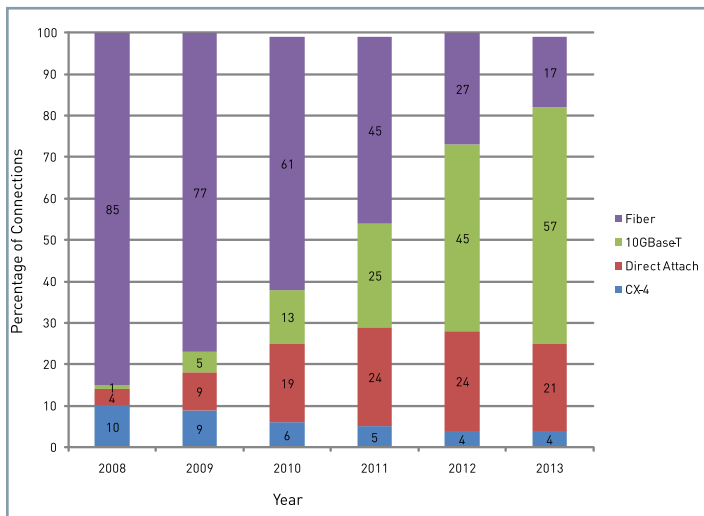


Figure 5. Physical media used to support 10 Gb/s in the data center is moving toward twisted-pair copper cable and 10GBase-T (source: Intel)

Most of the interconnection needs in the data center can be met with copper because of the shorter distances involved. 10GBASE-T can meet 99% of the interconnect needs in a data center, relegating fiber to longer backbones and making twinax cable an even smaller player. Category 6a twisted-pair cable is emerging as the most cost-effective cabling media in the data center. Cat 6a cable supports the major configurations used in high-density data centers:

- **Top of rack:** the switch is placed on top of each rack of servers.
- **End of row:** a single switch supports an entire row of racks.
- **Switch to switch**

Maintain Uptime and Reliability

The importance of uptime is, of course, one of the clichés of data centers. Cliché or not, it is definitely true; data center administrators spend a lot of time and effort ensuring reliable, continuous operation. For the most mission-critical data centers, the goal is 24/7/365.

The role of the cabling system in ensuring continuous uptime and application availability cannot be overlooked. After all, the cabling is the critical element in interconnecting all the electronics. Failure of a cable can bring down segments of the data center. Underperforming cable can slow operations. A high-performance cabling system must not only support current and future bandwidth requirements, it must also be able to handle elevated temperatures and electrical noise.

While electronics is upgraded fairly often, every 3 to 5 years, cabling systems are expected to last much longer, 15 years or more. You should install the highest performing cable available to support future equipment upgrades:

- **Cat 6a copper cable supports the migration from 1 Gb/s to 10 Gb/s.**
- **OM4 fiber-optic cable supports the move to 40 Gb/s and 100 Gb/s Ethernet in the backbone.**

As mentioned above, following the installation guidelines of TIA-942 will give you a flexible, scalable system that is easily reconfigured to meet the evolving needs of the data center. While a complete discussion of installation practices is beyond the scope of this paper, a few examples will highlight the importance of the passive network infrastructure in helping maintain a reliable network:

- **Properly manage and strain-relieve cables in the rack. Improperly managed cable bundles can exert downward pressure on equipment ports.**
- **Be aware of airflow and avoid cable routing that could impede proper airflow.**

¹ Brocade Communications Systems, Building a Reliable Foundation for Expanded Data Center Virtualization, 2008. GA-WP-1220-01.

- Don't skimp on cable and connector quality. Make sure performance has been verified by a third-party lab. Also make sure that cable assemblies have been fully tested for compliance to performance standards. The cost of the cabling system is only 2% to 3% of the data center: saving a few tenths of a percent may seem pennywise but it may prove pound foolish in future problems and degraded performance.
- For the same reason, don't short-change the passive infrastructure.

Lowering the Cost of Ownership

All of the foregoing should suggest the importance of the passive network infrastructure in helping to extend the life of the data center and to lower the cost of ownership. Smart deployment of the infrastructure—from specification to installation to ongoing operations—increases reliability, allows flexible MACs for easier data center administration, and simplifies upgrades to electronics. Here are some thoughts to keep in mind when designing a data center:

- Use racks, cabinets, and other hardware to enhance cooling effectiveness with passive airflow management. Such airflow management is a simple step toward high energy efficiency, lower cooling costs, and higher network reliability.
- Install future-ready cabling to allow the migration to 10 Gb/s over copper and 100 Gb/s over fiber. Cat 6a copper cable and OM4 fiber give you the best path to higher bandwidth to meet evolving needs. While these cables may cost more today, they are much less expensive than replacing cable with every cycle of equipment upgrades. Since the cabling system can be expected to last through several upgrade cycles, the best practice is to cable for tomorrow, not today.

- Use cable management hardware to eliminate unnecessary stresses on the ports of active equipment and on the cable itself. Stressing ports obviously can lead to equipment failure. Stressing cables, through kinks, overly tight tie-downs, or lack of support, can degrade performance so that the cable does not meet standards.
- Use the guidelines of TIA-942 to achieve a flexible, manageable structured cabling system. Not only is the standard based on structured cabling system using standardized architectures and media, it offers guidelines on efficient use of pathways and spaces for routing cable. It also helps the cabling system meet data center tiers for availability and redundancy.

Conclusion

As data centers combine high densities, higher speeds, and high complexity with the need to cut energy costs and meet green initiatives, the cabling system and the passive infrastructure are gaining an increasingly important role. A structured cabling system simplifies the administration of the data center by allowing easier moves, adds, and changes. It is also a key to supporting the high I/O speeds required.

The passive infrastructure, in turn, provides a basic structure for organizing, mounting, and interconnecting active equipment and for routing and managing the cabling system. Viewing the infrastructure more strategically allows you to specify the components with a view to improve cooling efficiency, control long-term costs, and meet evolving needs. From such basics as cold-aisle/hot-aisle configurations to cost-cutting airflow management, the passive infrastructure plays an active role in building better data centers.

Berk-Tek, A Nexans Company

132 White Oak Road
New Holland, PA 17557
Tel: 800-BERK-TEK; 717-354-6200
Fax: 717-354-7944
www.berktek.com

Legrand|Ortronics

125 Eugene O'Neill Drive
New London, CT 06320
Tel: 800-934-5432; 860-445-3900
Fax: 860-405-2992
www.ortronics.com