VERTIV WHITEPAPER

The Changing Role of Rack Enclosures in the Modern IT Infrastructure

Introduction

As computers moved away from the monolithic mainframe to the use of distributed systems with smaller individual servers, the utilization of the IT rack greatly changed.

New generations of high-density servers and networking equipment have increased rack densities and overall facility power requirements. Power density per rack averages 7-8 kW today and is expected to rise.

While large scale IT operations such as colocation facilities and cloud installations may have different rack requirements than edge of network or enterprise applications, the rack enclosure is still the backbone of the information technology infrastructure.

Racks Do Much More Than Just Hold Equipment

At one time, data center rack enclosures and related equipment were considered commodity products—simply a platform to stack equipment, with more enclosures purchased as servers and rackmount components were added to the IT inventory.

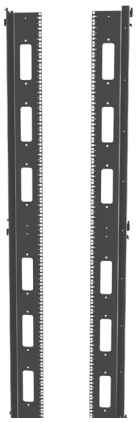
Today, even though the sophistication and criticality of the data center has soared, some may still assume that because a rack enclosure isn't electronic, it's basically a piece of furniture. In reality, today's rack enclosures are highly engineered equipment that can enhance the efficiency of supported equipment and improve the productivity of data center personnel.

Rack systems are strategic assets that play a key role in system uptime and data center availability and reliability. They can be counted on to be flexible and adaptive to accommodate rapid change. IT racks are designed for flexibility and ease of cable routing that contributes to time efficiency and productivity increases. They are, in short, a vital component of any data center.

Currently many racks are shipped fully configured with servers, UPS and power distribution components pre-installed, usually by value-added resellers (VARs) and system integrators. The rack enclosure has become the basic framework of the modern IT infrastructure. The growth of the colocation market has greatly contributed to this transformation. This is also driven by the need for speed of deployment. Many IT applications are revenue generating, meaning the sooner they are deployed, the faster they begin paying dividends.

This same dynamic of consolidation and integration has also occurred at the room or building level for data centers. Modular or pre-fabricated data centers can include all the infrastructure required to be fully functional including the IT racks and servers.

Racks Types and Architecture



IT rack enclosures are essentially metal frame structures that are designed for mounting standard 19-inch rackmount equipment including servers, routers, switches, UPS systems, audio/video, monitoring and communications, plus other components regardless of vendor. Rack enclosures have removable front and rear doors, removable side panels and adjustable vertical mounting rails. They provide equipment organization, security and cable management while enabling airflow.

A standard server rack cabinet is typically 42 to 48U (2000-2265mm or 78.6 to 89.2-inches) in height, 600 to 800mm (23.6 to 31.5-inches) wide, and 1100 to 1200mm (43.3 to 47.8-inches) deep. Newer server rack cabinets come with adjustable mounting rails allowing the user to place the rails at a shorter depth if needed. The 19-inch dimension includes the edges that protrude on each side which allow the module to be fastened to the rack frame with screws. Some specialized equipment utilizes 23" mounting rails. These can be installed on wider racks by replacing the 19-inch mounting rails.

Since the doors and side panels lock, they also provide physical equipment security. The front and rear doors are typically perforated for ventilation to provide ample airflow to the installed IT equipment that utilizes its own fans for air distribution.

Different types of end users have different needs for racks. Colocation and cloud facilities utilize thousands of racks in their facilities and are constantly growing, while edge and enterprise users tend to use fewer racks. IT racks must support a wide variety of equipment, including servers, storage, switches, routers, PDUs, UPSs, console port servers and KVM switches. The equipment in these racks must be installed easily, serviced efficiently and easily accessible.

Colocation and cloud users often specify custom engineered units. They work directly with the rack vendor's engineering and design teams to get exactly what they want. Because they are purchasing at higher volumes this kind of customization can be done cost-efficiently. For example, building a taller custom rack than the standard models that allow users to take advantage of headroom by expanding vertically. Other special features can include custom colors to match a specified appearance in a corporate data center. These customizations can be particularly important to colocation companies as the floor utilization and look of the data center is part of their value proposition.

Another factor that can influence the rack decision is Open Compute Project (OCP), an organization that shares designs of data center products among companies. Its goal is to design and enable the delivery of the most efficient server, storage and data center hardware designs for scalable computing. These organizations opened up their architecture to others having the understanding that if the edge/enterprise market would standardize on these systems the costs would come down.

The specific application and type of IT equipment to be housed will help determine the type of rack to be used, as well as the type of data center or location. Decision criteria includes:

- Electrical power distribution availability
- Cable management inside and outside the rack
- Whether cabling is run overhead or underfloor

Specific expertise is required in determining how to route all of the cabling in the most efficient way. Some facilities will also have dual redundant power supplies which adds further complexity to cable management.

While racks that are 42-48U high have been the standard, it is not uncommon for taller or shorter racks to be deployed, depending on the application. In cases where floor space is a premium or revenue generating space, such as colocation, taller racks are more common. For Edge environments, such as those listed below, the preference is sometimes for smaller racks due to a limited equipment need. This can be as small as 6-12U and include applications such as:

- Local data storage
- Point of sale
- Communications
- Video on demand

Different cabinet depths are also available, mostly driven by the need for more cabling access and additional power distribution. The taller the rack, the more equipment that is inside. This higher density, however, will have an effect on cooling and weight loading of the rack.

To accommodate switches and heavy networking equipment along with numerous cables, wider 31.5-inch or 800mm racks are available for these applications. The wider footprint allows for space on either side of the rails to be used for cable routing and management. Racks wider than 600mm are commonly referred to as networking racks

Because personnel who need to install or remove components within the rack are no longer strictly technicians or maintenance personnel, tool-less installation helps to save time during equipment deployment. The ability to add new components or change configurations at potentially a moment's notice makes installation a fast slide-in, slide-out procedure, a necessity in today's data center.

Easy Installation

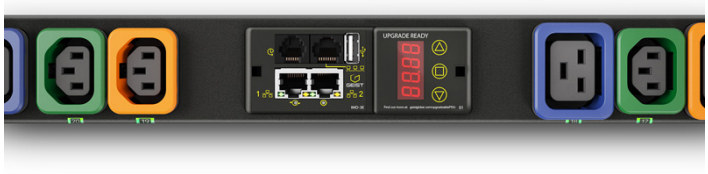
IT Rack Decision Criteria

What is the specific application and what type of IT equipment is required to be located in the rack? What is the type of data center or location where it will be used? Colocation and cloud applications are usually located in more traditional data center environments. Edge is a non-traditional application that can be found in many varied locations and may consist of smaller racks in single deployments or more traditional size racks in traditional data center spaces. Edge applications can vary widely depending on the application. Enterprise systems can be in data center type environments or in smaller server rooms or wiring closets depending on the size of the company and application.

Knowing the environment in which it will be used will help determine the type of rack and accessories to be used. In some cases, there can be quite a bit of engineering and design that goes into determining the rack architecture and floor layout.

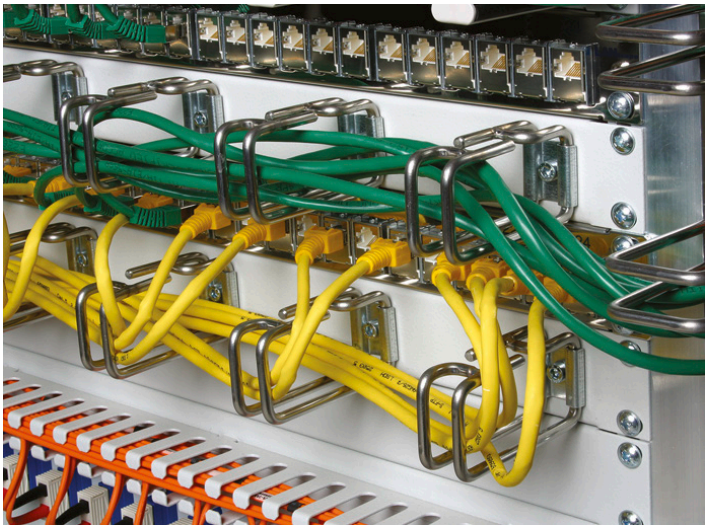
Power Distribution

Racks have traditionally been used as a mounting platform for the equipment housed internally, but they are also important for their ability to mount power distribution equipment, overhead cable management, and attachment points for aisle containment. Power distribution units (PDUs) are usually used within the rack to supply electricity to each component. The type and configuration of the equipment the rack PDUs are powering will determine the number of PDUs and outlet types needed. The number of servers, power needs and redundant power requirements will determine the number of rack PDUs, usually between one and four, required for the rack.



Cable Management

Cable management peripherals will help reduce signal crosstalk, as well as reduce the potential to block equipment access. This will protect cables from damage and keeping them out of the way during equipment removal. Correct arrangement of cabling will also help to maintain proper airflow paths. It is important that airflow not be restricted or blocked between the rails of a rack. Most cable management devices require no tools to mount and align with U markings on rails. Hook and loop straps and D rings may also be mounted throughout the enclosure to hold cabling.



Cooling

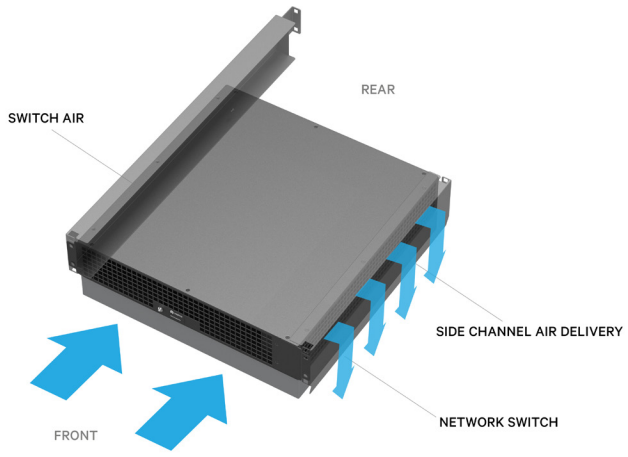
Airflow management peripherals will optimize efficiency. Blanking panels may be added to any unused U space, to ensure that hot-aisle air is not drawn back into the cold aisle and cold air distribution does not bypass the IT equipment. Vertical airflow baffles should be considered for cabinets wider than 600mm (23.6-inches), to prevent short cycling of air and maintain the hot-aisle/cold-aisle advantage.

Racks arranged in a hot-aisle/cold-aisle configuration enhance equipment performance and life. This is an industry best practice that arranges a data center with a cold aisle (two cabinet fronts facing each other) and a hot aisle for component exhaust (cabinet backs facing each other). This arrangement prevents hot air that has been expelled from one equipment rack to be drawn into equipment directly across the aisle. This practice optimizes cooling efficiency, extends equipment life and reduces potential damage from overheating. Further optimization and cooling efficiency gains can be achieved by containing either the hot or cold aisles.

The introduction of side-breathing equipment makes rack width a factor as well. Racks widths up to 1000mm (39.37-inches) are becoming common to meet equipment manufacturers' specifications that call for clearances from 150 to 280mm (5.9-inches to 11.02-inches). These clearances are required for proper airflow to the equipment and to provide ample cable management space. Often, airflow management accessories are required to make them compatible with hot aisle/cold aisle arrangements.

Networking

Units should be flexible to allow for all the cables required in a networking application. They should also be able to accommodate network switches that have side-to-side airflow and forward-facing ports.



Rack Density

Closed Loop Cooling

Open architecture systems utilize cooling coils near the heat load either inside or outside the open server rack and utilize the room air volume as a thermal storage to ride through short power outages. The closed loop architecture fully encloses the rack with the cooling coils inside. Other provisions are required for power loss ride through. This closed loop cooling can be used where a smaller number of racks have a high heat load.

Closed-loop enclosure air conditioners are mounted directly on, in, or adjacent to the cabinet and remove heat without letting outside air into the sealed enclosure. This type of system is typically used to cool electronic equipment that is housed inside a NEMA rated enclosure that protects sensitive equipment from dust and other contaminants. In the closed-loop system, the heated enclosure air is drawn into the air conditioner by a powerful blower where heat and moisture are removed as it passes through an evaporator coil and forced back into the enclosure, maintaining the NEMA integrity of the enclosure.

Perforation Patterns

Early racks enclosures did not have perforation. Today most rack manufactures provide doors with approximately 60 to 80 percent perforation for proper air flow (higher perforation levels improve airflow capability).

Predictions for Future Density

An average of 7-8kW of power is used per rack in most cases. As more server capacity is used, however, more power is drawn. Facilities are now being built out to handle somewhere in the range of 8 to perhaps as high as 20kW/rack with provisions for up to 30kW/rack in select positions or zones. In certain applications, such as geomapping, analytics and AI (artificial intelligence), the density can increase further to densities in the 40-50 kW/rack range.

Today's enterprise facilities are changing, adjusting to the proliferation of cloud and edge computing, and often shrinking and moving to higher-density architectures. This trend of moving workloads to colocation, hosting facilities and the cloud is expected to continue.

Height Driven

Taller racks are seeing increased use as a way to maximize floorspace use. The need also exists for taller, wider and deeper racks to accommodate the changes in IT equipment and densities. As data center managers strive to make use of valuable space, racks are being filled with more components and cabling than ever. While high density configurations can enhance energy efficiency, they also create a need for effective power delivery and thermal management.

These taller racks, beyond the common 48U (2265mm or 89.2-inches) have become more popular as data centers with room to expand vertically look to take advantage of headroom. The depth of rack-mounted equipment is also increasing which is beginning to see the need for rack depths beyond the standard 1200mm (47.8-inches).

Application Drivers

The rack has to be able to support the required cooling method that is being used. Driven by data intensive IT applications such AI, IoT, analytics. music/video streaming and others, higher heat loads are being seen within the rack and in more locations. These types of applications are generally found in larger data center environments but are now moving out to the edge as businesses such as movie streaming operations are now building smaller data centers in locations that are closer to users. No matter where it is located, the rack has to accommodate all of the necessary power and cooling features to make it a full solution for the end user.

The Rack Purchasing Process

Today, VARS (value added resellers) and system integrators are involved with the purchasing chain of the rack business. Cloud data centers often use integrators so that deployment can be quickly accomplished as they build out a data center and add new racks in these large facilities. In some cases, racks are shipped to a customer configuration center where servers, switches, UPS, power distribution and other IT components are added. Integrators can also provide full solutions to edge customers.

Edge users will often use standard racks and order through one of the large IT equipment distributors. Colocation/cloud users often prefer custom engineered units and will work directly with the rack supplier's engineering and design teams to get exactly what they want. For example, building a taller custom rack than the standard model or using custom colors. As mentioned previously, colocation/cloud facilities purchase at higher volumes so this can be done cost-efficiently.

In other cases, racks may be sold directly to the end user by the manufacturer or sold to an IT systems manufacturer who will sell it as part of a package to end users. If the user has facilities in different parts of the world, it can also be helpful to work with a rack vendor who has a global standard for its products.

Integrated Rack Shipping

Fully integrated server racks are designed to meet current IT market demands for on-site delivery of fully populated rack systems. To accomplish this, rack suppliers now use a specially designed shock packaging solution for shipping racks. This includes the use of a heavy-duty palate with foam cushioning, additional reinforcement and special wrapping to protect the rack and the IT equipment inside during shipment. Factory integration with power and distribution pre-installed in the rack is available.

The rack can then be shipped to a system integrator or VARs who can open up the shock packaging, add servers and other IT components to the rack, reassemble the packaging and then ship the entire rack to the customer. This process assures safe shipment and faster deployment of fully loaded IT racks for complete on-site system configuration.

To make sure the rack will ship properly, there is specific testing that takes place prior to packaging. This includes:

- **Static load** — how much weight can the rack hold.
- **Dynamic load** — how well will the loaded rack roll on its casters without tipping over. It must be stable.
- **Transit testing** — the shipping palate must absorb shock so that rack will be delivered without any damage.

Conclusion

The need to maximize IT system performance and ensure reliability has driven an evolution in rack technology. Today's IT rack enclosures offer features that improve the component installation process, protect the operation of critical computing systems and accommodate a new generation of equipment that is being introduced into the data center.

When properly designed and specified, racks are no longer just a commodity item, but a strategic asset that is a key element of delivering data center efficiency and reliability. Rack systems that are designed to facilitate growth offer the best long-term investment.

Rack selections should be based on the ability to deliver flexibility and reliability and lower the total cost of ownership over time. This approach ensures that users will get the greatest value from their rack selection and helps to ensure that the data center infrastructure will meet the needs today and into the future.

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