Essential Rack System Requirements for Next Generation Data Centers

White Paper #7

Revision 2

Executive Summary

Effective mission critical installations must address the known problems and challenges relating to current and past data center designs. This paper presents a categorized and prioritized collection of rack system challenges and requirements as obtained through systematic user interviews.

Introduction

In the late 70's companies began installing computers in rack enclosures; however, without multi-vendor compatibility installations were difficult. In 1984 the International Electrotechnical Commission (IEC) approved the IEC 297-3 standard as a means to standardize the mechanical dimensions of 19-inch (482.6-mm) enclosures. Other standards such as the EIA 310 (Electronic Industries Alliance) provided further standardization to rack mounting telecommunications and IT equipment. Despite these standards, the dynamic pace of the computer industry combined with its convergence with the telecom industry has caused problems that these standards are slow to address. In this paper, a systematic approach of identifying and classifying user problems provides insight regarding the nature and characteristics of rack systems in next generation mission critical installations.

This paper focuses on the problems associated with rack mounting telecommunications equipment and IT equipment in today's data centers. A related APC white paper #4, "Essential Power System Requirements for Next Generation Data Centers" addresses the related problems of providing power. APC white paper #5, "Essential Cooling System Requirements for Next Generation Data Centers" focuses on the problem of removing power in the form of heat.

Survey

A survey of management personnel relating to mission critical installations was conducted, interviewing corporate CIO's, Facility Managers, and IT Managers. Over 150 people were interviewed from over 90 different organizations including Fortune 1000 companies, Government and Education, and Service Providers. Approximately 50% of customers interviewed were from North America, 20% from Europe, and 30% from Japan, Pacific, Australia, and Asia (JPAA) region.

The one year survey utilized "Voice of the Customer" techniques, which relies on data collection of verbal and/or written responses to open-ended questions. This provides extremely unstructured responses, with the advantage that the responses are not limited or constricted by preconceptions within the question. During the course of the survey, some of the questions were expanded and/or changed in order to clarify ambiguous responses.

Results: Rack System Challenges in Mission Critical Installations

Survey responses were grouped according to common concepts, and for each group a solution requirement, corresponding to a challenge for mission critical installation design, was derived. This process identified 18 core challenges. These core challenges were then further grouped according to theme into the following 5 key theme areas:

- Lifecycle Costs
- Availability
- Maintenance / Serviceability
- Manageability
- Adaptability / Scalability

For each theme area, the challenges, underlying problems, and rack system requirements are presented in tabular form. The highest priority problems are listed first under each theme. The priority was determined by combining number of mentions weighted by priority as expressed by the respondents.

Lifecycle Cost Challenges		
Challenge	**Underlying problems**	**Rack System Requirements**
Vendor-neutral racks	Proprietary racks result in higher costs due to "unique" requirements imposed by IT equipment manufactures. Difficulty with mergers and integrations	Vendor-neutral rack manufacturer with economies of scale and guaranteed universal compatibility with all IT equipment. Pre-engineered solutions that eliminate and/or simplify most planning and engineering.
Accelerate speed of deployment	The time and work involved in server migrations and technology refreshes are costly both in downtime and labor.	Pre-engineered time saving solutions that eliminate and/or simplify planning and installation.

The survey found the lifecycle cost challenges were the most important requirement, particularly for respondents from top level management in their organizations.

The survey revealed that most racks sold by server manufacturers are less likely to be compatible with competitor's equipment. This is a problem given that most respondents preferred to standardize on one rack for a uniform and consistent look in the data center or network room as well as to eliminate the learning curve of a different rack.

Availability Challenges		
Challenge	**Underlying problems**	**Rack System Requirements**
Proper cooling airflow to IT equipment	IT equipment compaction and rising heat densities are causing equipment to fail prematurely. Servers are getting deeper and thinner which allows more servers to be installed in a rack and therefore more heat and cables. Customers don't know if the rack they are using is providing proper airflow for their equipment. The temperature up and down the front of a particular rack can vary 10°C (18°F). This effect is unexpected and the reasons why this happens are unclear to the users. This places unexpected stress on individual pieces of IT equipment and results in premature failure of equipment above the temperature gradient.	Well-designed perforated doors should have over 830 in^2 (0.53548 m^2) of ventilation area that can provide sufficient "unassisted" airflow to ventilate IT equipment in a 42U rack. Cable management should prevent power and data cables from obstructing exhaust airflow. Vendors that validate the cooling effectiveness of their rack designs using CFD (Computational Fluid Dynamics) and environmental chambers. Tightly sealed rack enclosures and accessories that prevent hot exhaust air from returning to areas on the front of the rack, and assure that cool supply air is distributed uniformly up and down racks.
Provide dual power sources to the equipment	IT equipment today is available with single and redundant power supplies but no provision is made for bringing power redundancy to the rack.	Easily configure the rack to provide dual power paths to single or dual corded IT equipment.
Physical security	In trying to provide ample air, power and data requirements, rack enclosures leave critical equipment vulnerable to sabotage or human error.	Hinges and fasteners located on the inside of the doors to prevent access to equipment. Doors should have unique combination locks combined with a master key or electronic locks integrated with the building security system. Side panels should be keyed.
Seismic capability (UBC)	Racks systems, located in Zone 4 regions of the U.S., that are not designed to be in compliance with the Universal Building Code (UBC) for Zone-4 seismic regions risk catastrophic lose of the IT equipment they are protecting.	All racks located in a Zone-4 region should be in compliance with UBC.
Minimize human error	Shallow and constricted racks have a propensity to exacerbate human error. Rack based power strips that use small unreliable circuit breakers can cause load drops and represent another single point of failure. Resetting a circuit breaker inside a critical rack can lead to further downtime.	Deep racks that allow ample room for working with less fatigue and visual obstruction. Remove circuit breakers from the IT rack. Use rack based power strips without circuit breakers for improved reliability. Circuit breakers should be easily accessible and located at the panel to avoid entering the critical IT rack.

The top availability problem for survey respondents was airflow to IT equipment. Given the dramatic increase in heat densities over the last few years, IT administrators are concerned that IT equipment will suffer damage due to inadequate airflow. To make matters worse, there exists no standard of measuring the cooling effectiveness of one rack enclosure over another. This is needed to insure a highly available environment for critical equipment. One method of ensuring proper cooling is to specify a rack doors that provide over 830 in^2 (0.53548 m^2) of ventilation area or doors that have a perforation pattern that is at least 63% open. Rack doors meeting these specifications can provide sufficient "unassisted" airflow to ventilate IT equipment. For poor cooling environments, supplemental air moving accessories are recommended for racks over 1,500 watts. The subject of rack cooling is addressed in detail in the following APC White Papers:

White Paper #29, "Rack Powering Options for High Density"
White Paper #44, "Improving Rack Cooling Performance Using Blanking Panels"
White Paper #46, "Power and Cooling for Ultra-High Density Racks and Blade Servers"
White Paper #50, "Cooling Solutions for Rack Equipment with Side-to-Side Airflow"

Survey respondents had negative experiences with rack based power strips that used unreliable circuit breakers. These inexpensive types of circuit breakers represent a single point of failure that is often overlooked. Furthermore, if they trip, it forces human intervention inside a rack filled with critical equipment. This risk is further increased by the fact that someone now has to locate the circuit breaker somewhere on the power strip. These issues are mitigated by locating circuit breakers on the same panel thereby increasing the availability of critical racks. By far the best way to increase power availability at the rack is to bring power redundancy to the rack. Respondents were surprised by the dramatic availability increase when dual power sources are brought to the rack, even for single-corded IT equipment. This subject is discussed in more detail in APC White Paper #48, "Comparing Availability of Various Rack Power Redundancy Configurations".

Serviceability Challenges		
Challenge	**Underlying problems**	**Rack System Requirements**
Decrease server migration delays	Problems inevitably present themselves which further delay completion of migrations and technology refreshes. Working clearances are restricted at times thereby increasing the likelihood of fatigue, injuries or downtime. IT equipment installations can sometimes take 3 to 4 times longer then normal due to rack mounting difficulties.	Rack depths should allow for ample work room thereby decreasing the likelihood of fatigue, injuries and downtime. Racks should incorporate tool-less features such as doors with quick-release hinge pins, quick-release side panels, and power and cable management, Racks should be able to roll through a standard door. Mounting rails should provide square holes instead of round tapped holes. Front and back mounting rails should have U heights clearly marked to increase speed of equipment deployment. Racks should offer split rear doors, “French doors”, to allow more working clearance in the aisles.
Cable management	Power and data cables can obstruct airflow causing damage to IT equipment that isn’t properly cooled. Difficulty in identifying power and data cables due to “rats nest”. Raised floors make it difficult to manage power and data cables and usually results in old cable being left under the floor.	Racks should be designed with integrated channels to allow for easy management, routing and storage of large amounts of cable. Data and power cables should be routed above the rack for easy identification and serviceability. Power and data cables should be stored in the rear of the rack for easy access and management.
Standardized racks for all servers	Server manufactures often state that the warrantee is void if a server is placed in a rack other then their own. Apart from aesthetics, this non-standard approach introduces complexity due to the unique characteristics of each rack.	Racks should exceed the server manufacturer’s ventilation and depth requirements. Rack vendors should guarantee compatibility with all servers. Racks should comply with the EIA 310-D standard.

Most of the serviceability challenges came from survey respondents that were directly involved with server migrations and technology refreshes. It was evident that improvements in this area are highly dependant on practical experience. Customers benefit tremendously from rack vendors who also provide cable management and server migration services, since knowledge gained in the field is used to improve rack designs.

Manageability Challenges		
Challenge	**Underlying problems**	**Rack System Requirements**
Monitor environmental variables at the rack	Difficulty in identifying thermal gradients from the top to the bottom of the rack which could shutdown and/or damage IT equipment. Difficulty in monitoring humidity at the rack. Difficulty in detecting smoke at the very early stages inside a rack.	Graphical user interfaces and automatic notification which report, manage, and notify based on environmental parameters at the rack level.
Monitor power attributes at the rack level	Difficulty in determining racks that have high thermal loads, and racks that are near overload. Difficulty in associating branch circuit loads with racks due to constant reconfiguration. For dual path systems, difficulty in determining whether remaining circuits will overload when one path goes down.	Graphical user interfaces and automatic notification which report, manage, and notify based on power attributes at the rack level. Ability to remotely and locally monitor the current drawn from the power strip(s) located inside each rack. This is especially helpful after adding new IT equipment.
Central management of IT equipment	Expensive and difficult to individually manage IT equipment that is distributed more and more throughout facilities.	Software and hardware solutions that allow IT administrators to centrally manage all equipment.
Monitor security at the rack	Racks are the last line of defense against sabotage to IT equipment but are often unmonitored.	Graphical user interfaces and automatic notification which report, manage, and notify security breaches at the rack level.

Respondents focused mainly on environmental and power management inside the rack. These management challenges closely resemble those discussed in APC white paper #4, “Essential Power System Requirements for Next Generation Data Centers” and APC white paper #5, “Essential Cooling System Requirements for Next Generation Data Centers”. However one unique management challenge that did emerge from the surveys (central management) was based on the growing popularity of server clusters. More companies are buying higher quantities of less expensive servers, which lower the cost of routine operations and reduce single points of failure. According to IDC research vice president, Jean Bozman, the developments in clustering technology have reduced the complexity involved in installing and maintaining server farms. An IT administrator today can buy pre-configured clustered server systems that don’t require specialized IT skills such as scripting. According to Dell senior manager of product marketing for clustering, Sanjay Sidhu, clustering is making its way into mission-critical environments [1]. However, a KVM switch isn’t enough to manage all these racks full of servers, IT personnel want a solution to centrally manage all equipment from one location.

Adaptability / Scalability Challenges		
Challenge	**Underlying problems**	**Rack System Requirements**
Plan for power density and cooling requirements that are increasing and unpredictable	Industry projections of equipment power density and related cooling requirements show great uncertainty but new rack systems must meet these requirements despite equipment refreshes.	Rack design that can be easily adapted, even retrofit, to house and allow proper cooling for high density equipment now and in the future.
Adapt to ever-changing power requirements	Different power requirements, voltage requirements, outlet requirements, even the need for DC may occur at any time in any rack.	A rack system that allows quick and tool-less changeover for different voltages, power capacities, outlets, and DC. Allow for rear mounting of power strips for easy power cord management. Power strips should provide up to 42 receptacles.
Adapt to changing data center and network room layouts	Sometime racks filled with equipment must be moved to locations that hamper the original rack configuration with regard to obstructions, and cabling.	Rack enclosures with field reversible doors with quick-release hinge pins, quick-release side panels, castors for mobility, and scales up to 2,000 lb (907.2 kg) capacity. Also, racks that adapt to new overhead power and data cabling systems.
Adapt to ever changing IT equipment requirements	Telecom and Internet markets are converging resulting in dynamic enclosure requirements that leave "holes" in racks. The cooling environment of these rooms becomes unstable.	A rack manufacture that can quickly modify their racks and provide tool-less accessories to meet these requirements. Adjustable mounting rails.

The solution requirements to meet the Adaptability Challenges are based on pre-engineered and standardized rack enclosures whose doors, side panels, rails, etc. can be easily changed in the field with no tools. To satisfy the rack challenges identified in this survey, there are a number of changes required from current design practice. Most of these changes arise by viewing the rack as the heart of the data center, for it is at the rack level that a company's critical IT processes are ultimately carried out. No longer should the rack be thought of as just a metal enclosure and specified based on little more then price. The rack enclosure provides a highly available environment that, when designed properly, can add measurable probabilistic uptime and cost savings to a company. Indeed the rack should be considered part of the data center or network room infrastructure which requires it be an integral part of power, cooling, security, management and fire detection systems. Only then will rack vendors have the foresight to provide solutions to the problems identified by this survey as well as the problems yet to come.

Conclusions

A systematic analysis of customer problems relating to rack systems provides a clear statement of direction for next generation mission critical installations. The most pressing problems that are not solved by current design practices and equipment have the common theme of the inability of the data center or network room to adapt to change. Rack systems must be more adaptable to changing requirements, in order to improve both availability and cost effectiveness.

In many industries, a maturity level is reached where new advances in reliability, cycle time, and cost require standardization, pre-engineering, and modularization. Designers of mission critical installations, designers of the rack systems used in them, owners should consider whether this point has been reached. IDC predicts that by 2005, 62% of all worldwide server unit shipments will be in a rack-optimized form factor. This puts further pressure on the notion that the rack should be considered and designed as part of the mission critical installation as the results of the survey in this paper suggest.

References

1. Lyman, J., *Supporting Server Clusters*, News Factor Network, November 1, 2002. www.newsfactor.com/perl/story/19843.html