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Server Technology White Paper

Power Distribution as a System within the High-Density Data Center

White Paper STI-100-016
Oct 2015

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Server Technology
Quality Rack Power Solutions

Overview

It has been obvious for some time that the power distribution system within the data center is the key opportunity to focus upon in order to actively manage the rising costs of power and more specifically, identify problems and waste in real-time. With future-thinking organizations sharing knowledge between Facilities and IT, the push for more intelligence within this rack-based power infrastructure has become urgent with higher rack power densities. In fact, proactive power management at all stages in the distribution chain within enterprise data centers has become the requirement to feed efficiency studies and data center infrastructure management (DCIM) style optimization initiatives.

The Modern Data Center

For years, the only high-priority concern for the data center manager had been that services were running. The IT side of the house paid little attention to the topics of power and cooling as these resources seemed limitless and were under the scope of the Facilities side of the house. IT professionals knew power would be available. SLAs and uptime were all anyone cared to talk about. “Give me five nines,” was a common demand, with little concern for incurred costs, power usage, or efficiency. Design and management of the facility services was only about redundancy, with over-provisioning of the power and cooling systems being the standard practice. For too long, companies simply allocated a budget to data center operations without the knowledge of exactly how that money was being used. IT was a black box and a blank check. As demand, density, and compute needs increased, this proved unsustainable and had to change.

Several years ago, we noted that there was only the rare organization that was not talking about efficiency, monitoring, power costs, or “being green.” Competition, government intervention, market pressures, and a dose of common sense had driven organizations to an understanding that to survive, a complete understanding was needed for where every piece of IT gear was being deployed, what services it was providing, and where each watt-hour was being used. With that group of goals, the next step was often further analysis by any one of a wide range of DCIM solutions on the market.

In just the past three years since this paper was first introduced, we have experienced even further tightening of the data center power budget through consolidation efforts and the building of higher density data centers. Where 42U 5kW cabinets used to be the norm, many newer data centers are now provisioning 45U-52U 17kW cabinets. In addition, these data centers are being built in a highly modular fashion with the understanding that growth can be rapid and unpredictable.

PDU’s as a System

What are the System aspects of power distribution? It starts with being able to treat large populations of PDU (Power Distribution Unit) devices as a single system. Individual intelligent PDUs, just like other devices within the data center, must be maintained with operating-system updates, feature/security patches, and configuration details. When looking at power distribution as a single system, this requirement for individual attention must be eliminated; however, the system should also retain access to all of the highly intelligent features from the individual component devices themselves. This may include highly accurate reporting on power consumption, the ability to remotely access metrics and power

state, and in many cases highly secured means of switching power at the device level.

The need for a complete intelligent energy monitoring system that provides for easy configuration, versatile reporting, capacity planning, and seamless integration is a critical requirement of any large-scale data center power solution. The power distribution devices within each rack are the final link in the power chain leading to the IT device loads, and as such the rack PDU is a perfect place to accurately measure power for use in metrics such as the Green Grid's PUE or the more recent DCeP metric. With the continuing metric work being conducted by the Data Center Efficiency Task Force and release of data center energy-focused white papers such as The Green Grid's "Recommendations for Measuring and Reporting Version 2 – Measuring PUE for Data Centers," and ASHRAE's "Thermal Guidelines for Data Processing Environments", there has been a growing level of support to actively manage energy and benchmark its results via key performance indicators such as PUE and DCeP.

A number of other papers have been written on the means to meet efficiency goals covering power distribution strategies, power chain configuration, device specs, cooling methods, and software tools to monitor these parameters. What is often overlooked is a coherent way to monitor, manage, and control a large number of like component pieces as a single entity.

This paper will describe how tens, hundreds, or even thousands of rack PDUs can be managed as a single continuous layer with easy configuration. It is this power layer that provides information on the energy usage of the IT load within the data center through versatile reporting which is then used for PUE, DCeP and other metrics. This paper will also show how implementing and configuring a proper energy management system eliminates much of the time and stress involved in monitoring power for capacity planning in the high-density data center and provides the additional means of seamless integration with continued DCIM efforts being planned and implemented by the vast majority of global enterprises.

Power Layer Challenges

The challenges that data centers face today are an extension of the challenges of yesterday. The rack PDU power layer is viewed as one of the single most critical components of the modern data center and new solutions are being evaluated in several key areas:

- System approach to large populations of rack PDUs
- Reliability in higher temperature environments
- Rising power and equipment densities throughout the data center
- Device-level power monitoring within the rack/cabinet
- Accuracy and depth of energy metrics
- Secured state control
- Environmental awareness
- Version control / device management and configuration
- Support for DCIM initiatives
- Overall value

System Approach
As described in the preceding section, adding intelligence for monitoring and management of power layer devices to achieve understanding of energy usage, efficiency, and cost has created the additional responsibility for managing those devices. For the rack PDU, it is necessary to find an effective means to handle updates and configurations to the hardware, as well as an effective means to handle the vast quantity of measurement data available from that hardware.

Reliability
Even with the current focus on efficiency, the goals of uptime and reliability of hardware will continue to be the number one priority for any business that relies on the operation of their data center. Any portion of the power distribution chain, including the rack PDU must maintain the expected long-term quality and reliability in the face of all pressure to account for every penny spent in the data center. Good data center designers and operators know this and seek out such quality devices. This becomes more important as we prepare for much higher density requirements (upwards of 20kW per rack/cabinet) and much higher temperature 'Hot Aisles' (60-degrees C or more).

Rising Power and Equipment Densities
Getting more for less is the mantra of many leading "big data" driven data centers. They are packing more equipment into less space and utilizing ever more power regardless of how efficient individual devices get. This high-density data center model requires a modular approach to defer capital expenditures until absolutely needed. In this situation, it is critical to understand exactly where the power usage lies at every level in the power distribution chain and to attempt to predict the time to increase capacity.

Device-Level Power Monitoring
In order to get the most detailed level of power consumption information in the data center, one must get metrics from the point of use. From the PUE/DCeP perspective, this is best accomplished at the input to the IT devices. Rack PDUs with outlet-level measurements allow for an organization to meet this goal. With information about the actual usage of devices, the data center / IT management can make better decisions, not just about which equipment to use, but also when to use particular applications. In the long run, analysis of this information helps with gaining fully optimized utilization of power and IT infrastructure.

Accuracy and Depth of Energy Metrics
The accuracy and granularity of the metrics available from the chosen PDU is extremely important. While previous generations of PDUs had little or no power monitoring capability, the requirement to obtain highly granular and accurate measurements is paramount to ongoing optimizations. Whereas many early-generation intelligent PDUs may include amperage as the only metric, the most advanced power handling devices include the entire scope of energy awareness: Amperage, Voltage, Wattage, Power Factor, Energy (kWh), etc. at multiple locations within the PDU. These are all critically important in understanding where, when, and how efficiently power is being utilized; and in making decisions regarding changes, improvements, and growth according to the needs of the business the data center supports.

Secured State Control
The means to control secure access to any and all devices within the data center is important. The rack PDU with switchable outlets answers this challenge and allows device reboot, outlet lockdown, firmware re-loading, etc. For many customers, outlet-level control is a perennial concern to the data center manager. The right people need to have the right access at the right time – no exceptions. Only the highest level

of security should be considered at these control points.

Environmental Awareness
Understanding environmental conditions within the data center rack/cabinet, especially as power density increases, is also of concern to the data center manager. Support for environmental sensors, which can be deployed easily without consuming significant hardware, cabling, or costs is a natural fit for the power distribution devices inside cabinets. Sensors can provide direct feedback on how the associated power is being transformed into heat and indirectly what portion of it is being transformed into wasteful heat.

Version Control/Device Management and Configuration
Intelligent monitoring and management at the rack PDU typically comes from embedded firmware. Such firmware, just as your common computer software, goes through revisions to add features or fix bugs. It is critical that this is managed in a controlled fashion to keep important factors like reliability and security up to standards. Since PDUs exist in each and every rack deployed across the enterprise, the number of additional devices that must be maintained or updated becomes staggering. The chosen energy management system should allow the entire population of PDUs to be maintained simply and conveniently.

DCIM Support
Intelligent rack PDUs coupled with a powerful energy management system are a requirement for organizations that are planning any form of DCIM effort over the coming years. DCIM itself is a rapidly growing market segment that relies on the intelligence from the power layer to create much of its value. For some organizations, the full DCIM solution is a day-one requirement; but for others, the initial outlay of cost and time causes a scale-back to a more manageable energy management system solution. For those who choose to start slowly, it is important to choose an energy management system that can be easily integrated into a full DCIM solution.

Overall Value
It is one thing to select the rack PDU that has all the desired features; it is quite another to configure, install, and implement them to meet the goals of power monitoring and management. Ease of setup and day-to-day use of the information flow has become a major concern in the data center. Without a plan and the right tools, it can be easy to fall behind in those monitoring tasks. This is where the selection of accurate, reliable, easy-to-use PDUs and an energy management system comes in. Having the necessary data to make decisions in the data center with a minimal investment in capital and time is how overall value is delivered.

Data Center Energy Intelligence

Given the challenges listed in the previous section, it is obvious that there is great value when you deploy an intelligent power distribution system in conjunction with a well-designed energy management system. You get a tremendous level of energy awareness, and it is this energy awareness that directly feeds all DCIM initiatives underway. You get a means to understand and manage all aspects of data center power at the rack level, without incurring unreasonable new management overhead. And, if these things are chosen wisely, you gain Easy Configuration, Versatile Reporting, Capacity Planning, and Seamless Integration along with many other valuable tools.

Easy Configuration
In addition to setting thresholds, alarms based on a measurement point only mean something if portions of the power system are properly named. Basic asset management is often built into an energy management system for this purpose. Additionally, some systems allow for more detailed configuration management of devices for firmware version control, communications link control, and access control.

Versatile Reporting
It is not sufficient to take measurements occasionally and claim an understanding of the power usage in the data center. Continual measurement of the IT device load, as recommended by the Green Grid (Level 3 measurements) for PUE and DCeP, is important to truly understand capacity used and to gain insight into the future trending of power usage at every step in the power chain. A well-designed energy management system will provide data output in such a way as to reduce workload in daily, weekly, and monthly tasks without adding onerous upkeep tasks.

Capacity Planning
One of the common reasons to implement an energy management system is capacity planning, especially in the high-density modular data center. Understanding not only how much power is available, but also exactly which circuits it is available on, is important for optimizing use of the data center infrastructure. Monitoring at the rack PDU is the most optimal place to understand the breakdown of power usage throughout the data center. Not only can one use the measurements at the rack/cabinet for understanding the capacity overhead of the branch circuit, but properly aggregated, the amperage of all stages of distribution upstream can be estimated.

Seamless Integration
Although for many organizations the desire continues for the all-encompassing single-system for monitoring and managing all devices within the data center, it has become clear for many that the specialized tools available today provide the best price for the value given. These tools may focus on any one layer such as the rack power distribution layer, the networking layer, the server utilization layer, or the cooling control layer, among many others. The most important aspect of these specialized tools is that they are easily integrated into those larger DCIM or BMS systems when the time and need arises.

Power Management
The ability to control the power state of outlets in the data center is controversial in some industries and essential in others. Whether rebooting locked up servers or switches in remote locations, turning off unused outlets to avoid accidental overloading of circuits in the data center, or providing scheduled outlet usage in lab applications, switching outlets has its place and certainly has its value. With high levels of security and user authentication, some rack PDUs are up to this challenge, incorporating a Secured Outlet-State Control feature. Selecting an energy management system with basic asset management can allow for convenient On/Off/Reboot commands of individual outlets, groups of outlets representing a single device, and clusters of outlets representing groups of devices.

Power Chain Integrity and Redundancy
It is a common goal to be able to monitor every device in the power chain from PDU to server. However, when it comes to implementation, cost can be a factor. If a data center can only measure at one place, measuring at the rack/cabinet in-feed with an intelligent PDU is the best way to get the most information.

An energy management system should be able to provide appropriate aggregation of the power measurements at the rack/cabinet. This can help prove redundancy within the rack/cabinet as well as at upstream points in the power distribution chain.

Alarm Management

Monitoring of power does one no good if threshold alarms are not properly managed. A simple, convenient way to mass configure the thresholds in multiple rack PDUs is very valuable. In addition, it is typically required that all alarms for like devices be accessible in one location. Some energy management systems have this ability and the ability to display alarm conditions and forward them to other systems.

Troubleshooting

Quite often, too much of life in the data center is "fighting fires." When urgent conditions show up through an alarm, it becomes ever more important to understand the progression that led up to that alarm. High amperage, tripped breakers, downed equipment – these are of critical concern to the personnel trying to maintain uptime at a maximum. Quick response to an alarm is of high importance, but it is better to prevent those conditions in the first place. Only through continual monitoring can one learn how to prevent recurrence of faults in the power system.

The Server Technology Solution

As previously mentioned, the actual implementation of a full-scale DCIM can seem daunting. To make it more manageable, Server Technology has developed a power and energy management system which takes the quality and usefulness of their own PDU family, multiplies it by any number of cabinets in a data center or network of data centers, and overlays it with the aggregation capabilities of Sentry Power Manager (SPM), an appliance-based tool that manages PDUs across the Enterprise.

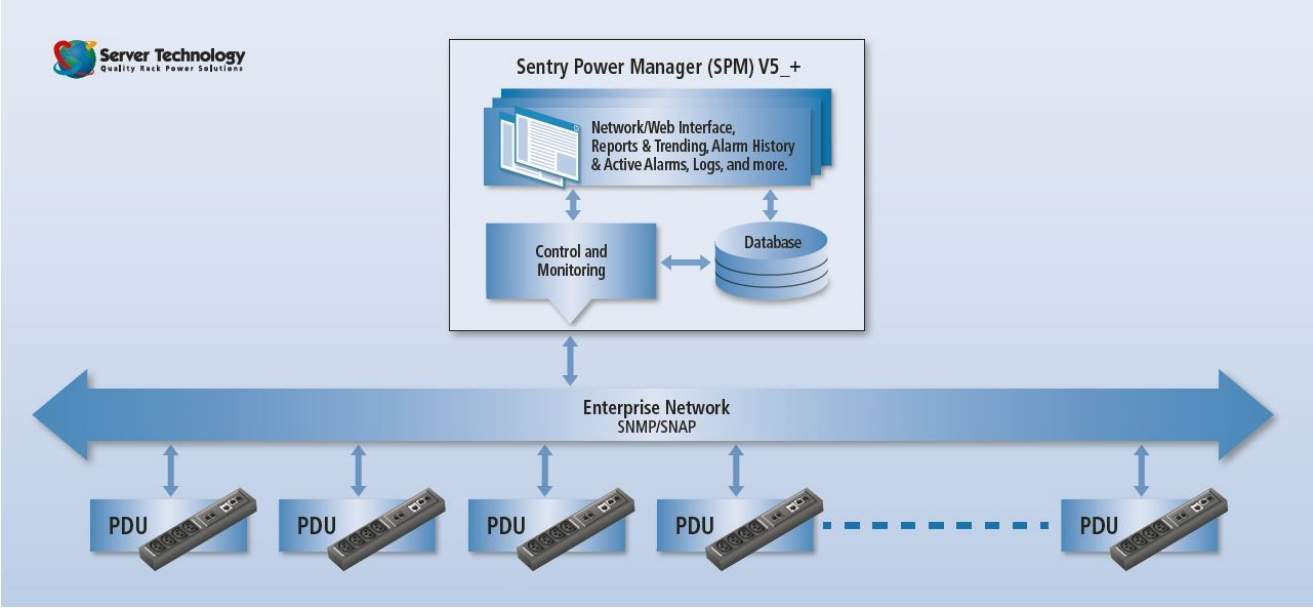

Figure 1: Server Technology's Management System

Part1: The industry's benchmark for the modern rack PDU

Taking the items in the previous sections as goals, the first stage of the solution is Server Technology's intelligent rack PDU with its patented Quality Power Architecture (QPA). Providing reliable hardware, accurate power measurement, monitoring of internal conditions, and power management capability with alarms, this PDU is the base component for any well designed power distribution and monitoring system. Figure 2 describes how an internal communications bus continually monitors all sub-sections of the intelligent rack PDU and serves up the data to the user with both secure Web-based access and serial access via command line. Information can be provided via SNMP to other systems as well.

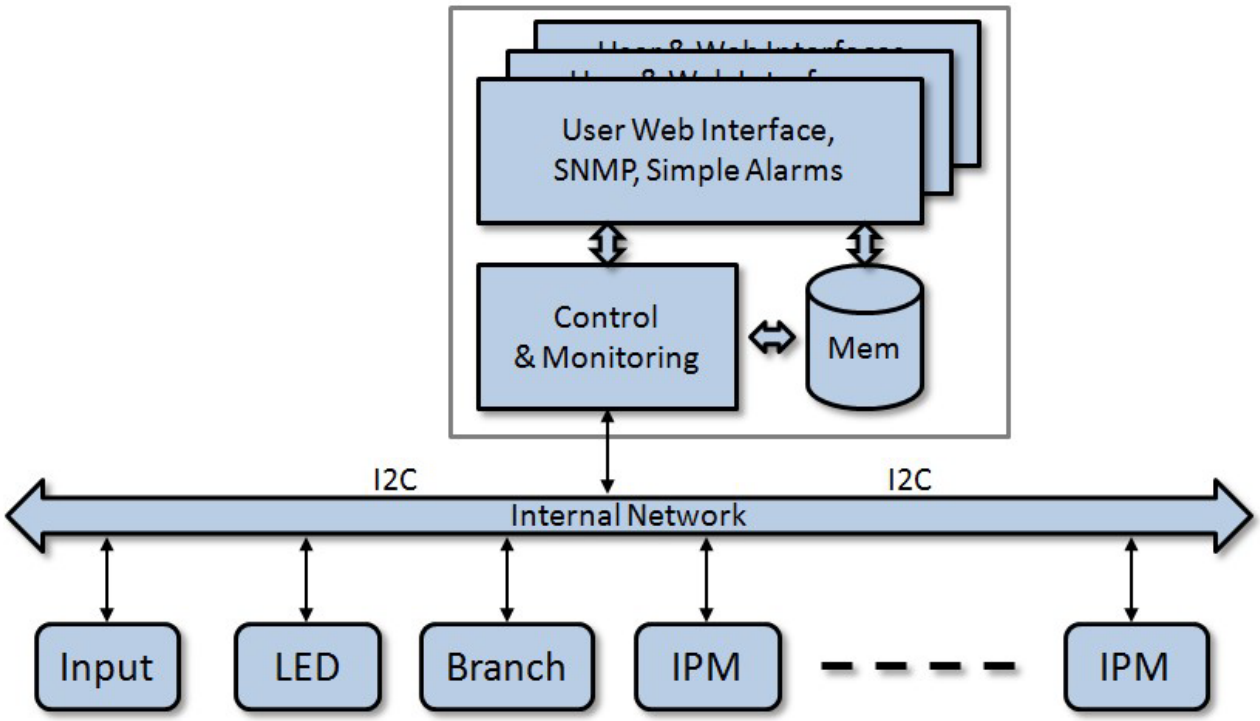

Figure 2: Server Technology's patented Quality Power Architecture

Quality is inherent in every Server Technology PDU. From design through manufacture, the ISO 9001 quality system helps produce the highest standard of quality. This includes rigorous verification and validation testing under extreme conditions, subassembly inspection and test, and 100% Performance Testing of the final product. (Not a sampling of units from the final assembly and test process, but EVERY single unit is tested before it leaves the factory.)

Consistency, through high-quality designs, is how high-accuracy measurements are possible using Server Technology's Per Inlet Power Sensing (PIPS®) and Per Outlet Power Sensing (POPS®) technology. These products are considered the benchmark for reliability and accuracy in the data center. Server Technology has completed an independent evaluation of the accuracy of its PDUs based upon the recognized standard for power measurement, ANSI C12.1-2008. Underwriters Laboratories (UL) has conducted tests which confirm that the measurement capabilities of these PDUs are ±1% billable grade accuracy for data center applications. In addition to current (amperage) measurement, these PDUs includes a wide range of metrics including power factor and accumulated energy, which can help spot inefficiencies.

Server Technology provides the widest range of power distribution units on the market, from 120V/20A to ultra-high-density 100A 3-phase 208V and 63A 3-phase 415V along with 600A -48VDC distribution. And many variations of outputs, physical form factors, and feature sets give the data center manager the solutions needed for all installations. Continuing innovation of the rack PDU provides features such as smart load shedding, selective outlet-control disable, locking and high-retention outlets, high-density outlet technology (HDOT), alternating-phase outlets, hot-swappable network card with redundant power connection, auto-flip LEDs, Power Pivot input, and more to come.

Part 2: Sentry Power Manager - The industry's richest power and energy management system

Polling all of the data and status conditions from the multitude of rack PDUs in one or more data centers can be quite a task. There are many SNMP-based tools on the market to provide this capability, but none provide the full feature set and ease of use and implementation that Server Technology's Sentry Power Manager (SPM) solution can provide. SPM provides the same high level of access and data as the Server Technology rack PDU and meets the additional data center challenges described in this paper.

Figure 3 solidifies the analogy that the SPM energy management system really is an extension of the reliable architecture built into the Server Technology rack PDU. Using both SNMP and Server Technology's proprietary SNAP™ communication protocol, SPM can provide Easy Plug and Play Configuration of rack PDUs, Versatile Reporting of power and environmental data, Capacity Planning tools for data center growth, Seamless Integration to other data center monitoring tools, and much more to meet the challenges of today's data center.

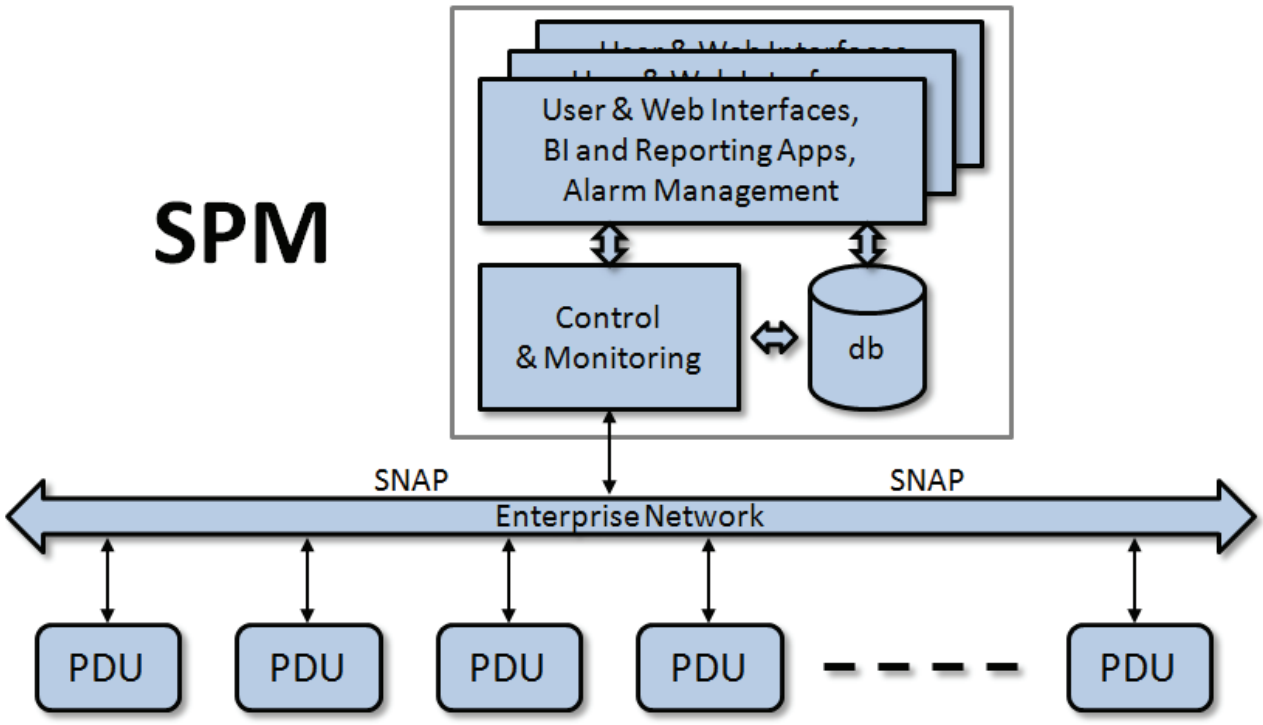

Figure 3: Server Technology's Sentry Power Manager

One of the most critical requirements of any configuration management and monitoring system is that of traceability. Knowing who did what and when it was done is an important part of change management and of troubleshooting. With SPM, all records of alerts, user actions, logins, and configuration changes are kept in system with the means to output via Syslog and via alert emails to responsible personnel.
Use SPM for firmware version control of particular PDUs, groups of PDUs through the zone feature, or entire locations full of PDUs. Server Technology's rack PDU firmware updates are freely available on the company website. The PDU is capable of updating its firmware via FTP using the SPM server as the source location.

One of the most important aspects of system configuration and continual use is that of simple graphical capabilities. SPM provides an easy to use hierarchical map view to readily identify alert conditions, relative power and environmental measurement values, and power capacity availability. With basic asset management in a spreadsheet format, SPM can be used to quickly identify racked equipment in terms of name, U-location, U-size, and outlets used.

Sentry Power Manager, using Server Technology's secure SNAP™ technology, provides the means to quickly bring the Server Technology rack PDU into view for data center personnel. Bringing new PDUs into the system is a "snap." Using templates full of critical system settings, SPM can push initial setup information automatically upon discovery of new PDUs on the network. Additionally, as organizational conditions change, PDU settings for security, access, measurement thresholds, and alarm management can be configured en masse just as one would for a single PDU.

With the PDUs being setup as desired, the measurement data is continually collected by SPM. This data can then be aggregated to understand power and energy usage of cabinets, zones, and whole locations when using PDU inlet monitoring or energy usage of outlet groups (IT devices) and outlet clusters (group of IT devices) when using PDU outlet monitoring (through POPS).

With the goal of data center power monitoring, it is often a challenge to get monitoring devices at every stage of the power distribution chain. In lieu of actually having measurement hardware at upstream PDU devices, the SPM advanced Circuit feature allows for data center personnel to understand the amperage load on each phase of every component in the power distribution chain. This is done through proper aggregation of the cabinet amperage loads. Using this Circuit feature, alerts can be set on total load which will help prevent overload of circuit breakers upstream of the cabinet. Finally, load balancing on a scale larger than each cabinet can take place which is particularly helpful in single-phase/3-phase mixed installations.

If you have legacy "Brand B" intelligent cabinet PDUs, SPM has the ability to get power related data, control relays, and get environmental sensor data from those devices as well as set thresholds and outlet states dependent on model. Additionally, SPM has the ability to add user-defined power devices for upstream circuits. For those installations with SNMP-enabled UPS, PDU, or RPP, custom devices can be built in the system to directly monitor those key points in the power system.

After creation of useful groups, clusters, zones, circuits, and locations, the primary measurement data from the rack PDUs as well as those aggregated values are available to users of SPM through integral Trends and Reports. These tools are critical for a true understanding of capacity available and system efficiency. Trends can be used to identify peak loads and environmental conditions over time, identify

which circuits and sub-circuits have free power capacity and identify opportunity for improvements to be made in terms of what time and which equipment various application loads might be assigned. Reports can be used to take spot measurements, or accumulate energy usage over time for efficiency analysis. Converting large amounts of raw measurement data into powerful information that can be used to make improvements in the data center is what SPM does best. Alternatively, gain access to the information through another system with the use of an API which is accessible via standard XML-based toolsets like SOAP and REST.

Finally, scheduling tasks to take place automatically is the ultimate ease-of-use feature. SPM allows for rack PDU discovery and setup, power management controls for switchable outlets, and emailing of pre-configured trends and reports to be run on a schedule as desired.

Summary

The power challenges within the data center due to today's market pressures have generated a tremendous urgency within organizations trying to meet these challenges. Identifying a system for power distribution within the data center that includes the highest quality and reliable hardware as well as an energy management system that ties it all together is clearly the critical first step. When selecting this system of power, tactical and strategic requirements must be considered. SPM provides an easy to manage system regardless of the topology or scale involved, provides highly accurate and granular monitored metrics at the rack level, allows highly secured state control, reports associated environmental information in the vicinity of the PDUs, and allows the simple and ongoing configuration and firmware version control across hundreds or thousands of devices deployed across the enterprise.

While the wealth of information flowing from the energy management system will be valuable by itself, the most capable systems for data center power will be specifically engineered to feed into ITSM and DCIM solutions for the ongoing data center management task. Lastly, the rate in which change is happening across all aspects within the data center requires that power systems be built with intelligence beginning immediately, as any acquisition today will span the timeframe for additions of dynamic computing, DCIM, and much of the vision of future Data Center.

Sentry Power Manager by Server Technology has been designed from the ground up to be the industry's most compelling energy management system, with specific attention paid to the ongoing management of the individual components as well as delivering the most accurate and detailed power metrics available. Worth a special note: a power system is only as good as the company behind it, so Server Technology personnel are there to help you plan, implement, and improve your power distribution infrastructure of any type and any scale.