Optimizing Data Center Efficiency: A Prescriptive Model for Reducing Energy Consumption and Improving Performance

An ENTERPRISE MANAGEMENT ASSOCIATES® (EMA™) White Paper
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Executive Summary

Faced with expanding IT requirements and diminishing operational budgets, today's enterprises need to adopt new data center infrastructure management processes in order to achieve business goals. Fortunately, solutions for efficiency improvements and cost reductions can be introduced to simplify management practices, improve reliability, enable informed decision-making, minimize energy consumption, and facilitate cooperation across siloed organizations. In this ENTERPRISE MANAGEMENT ASSOCIATES® (EMA™) white paper, EMA expands its popular IT Management Maturity Model into a Prescriptive Model that provides actionable steps for optimizing Data Center Infrastructure Management (DCIM).

Managing Today's Dynamic Data Centers

The data centers of today are evolving. As enterprises move from distributed computing resources to more centralized operations, data center configuration and management has become more critical to business success and profitability than ever before. Web commerce, virtualization, data warehousing, regulatory compliance requirements, and an increased use of digital communications have all contributed to the growing reliance on data center resources. A report issued by the U.S. Environmental Protection Agency (EPA)[1] indicates data center capacity is expected to grow 10% each year over the next decade. The same report indicated increases in the total national data center energy consumption are expected to reach 120 billion kilowatt–hours (KwH) by the end of 2011, which is roughly equivalent to the total amount of power consumed by all the nation's household lighting and four times as much collectively consumed by all American color television sets. At that point, U.S. data center power consumption alone will account for a whopping $7.4 billion dollars in annual electricity costs.

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Certainly the accelerating costs associated with expanding data center energy consumption are a major concern of fiscally responsible organizations, but the implications extend well beyond budgetary concerns. The environmental impacts of increased energy usage have led many governmental bodies to introduce compliance initiatives to curb power consumption. In 2008, for instance, the European Union launched "The Code of Conduct for Data Centers," a voluntary program instituting energy efficiency best practices. "Cap and trade" policies that place a specific limit on how much power a business is permitted to draw have also been enacted worldwide. Enterprises can actually earn revenue from these programs by utilizing less energy than their allotment and trading credits for the unused portion in an open commodities market. At the time of this writing, legislation for a "cap and trade" program is currently pending in the U.S.; however, several voluntary programs are actively in use.

The direct effect of drastic increases in power requirements, however, represents only a portion of the infrastructure challenges inherent in today's larger, more business-critical data center implementations. IT resources must be extremely agile so they can be updated, reconfigured and expanded rapidly to meet changing business requirements. This can be an extremely expensive undertaking as the alteration of existing systems and the introduction of new resources involve both capital and operational costs.

[1] Report to Congress on Server and Data Center Energy Efficiency – U.S. Environmental Protection Agency, Energy Star Program

This fact is even more challenging for organizations that have already reached the limit of their available data center capacity. The only options for these data centers are to take the very costly measures of expanding the existing physical data center facilities or take steps to maximize the existing space and facility utilization – the latter obviously being the more pragmatic and cost-effective approach.

The primary method currently employed for improving data center energy, space, and performance efficiencies is to consolidate servers onto fewer but more powerful platforms (such as blade servers, mainframes, and supercomputers). In fact, according to EMA primary research[2], roughly 80% of organizations that have introduced data center efficiency programs adopted server consolidation strategies as a key part of their solution. However, this approach introduces a series of new challenges for IT management. Identifying which services are most appropriate for consolidation, determining the optimal configuration of the infrastructure, and the management of more complex hardware platforms all contribute to an increase in data center management concerns. Virtualization platforms, a key enabler of server consolidation initiatives, have added an additional layer of complexity to the management challenges by obfuscating which logical services are operating on which physical systems. For instance, management tools designed to support traditional environments are often unable to effectively or efficiently recognize and support virtual infrastructures. Also, since it cannot be easily determined where a virtual instance is physically located, it is more difficult to restrict user access using standard authentication methods.

Lacking insight into both business IT requirements and physical data center infrastructure utilization, many organizations are unable to make informed decisions on how best to optimize their environments. This lack of insight between the related physical infrastructures impacts the amount of true utilization of resources that is possible. Each time a new technology is introduced, peak "buffers" are put in place to guard against over-provisioning and failures in availability. It is not uncommon to see additional cushions against peaks of 10-20%, thereby hindering the data center's ability to achieve maximum optimization.

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Dealing with Segmented Organizational Structures

The first step to proactively transitioning to a more productive and cost effective data center configuration is identifying how the business relates to IT resources. In most organizations, this will immediately reveal one of the principal barriers to data center optimization – segmented organizational structures. Facilities management is typically responsible for data center environmental conditions (such as power availability, temperature control, airflow, and space allocation), and IT organizations retain control over individual servers, networks, and storage units. Often, these two organizations are managed and funded separately, with each being mandated to achieve different sets of business goals.

Making matters worse, IT organizations are often themselves segmented into disparate groups for supporting IT disciplines (networking, systems, storage, desktops) or platforms (UNIX, Linux, Windows, virtual tools) or dedicated to supporting specific projects. Since any data center optimization strategy will affect services provided by multiple organizations, there needs to be clear cooperation across the organizational structures. This is not always easy to achieve, as each group is more focused

[2] The True Value of Green IT: An EMA Research Report

on achieving its primary support responsibilities than spending time on environment improvement projects that may not be credited toward its performance. Consolidation initiatives are particularly difficult to introduce into segmented support environments, because they usually involve combining services from multiple independent projects that are separately managed and include different dependencies and requirements.

To ensure participation across siloed organizations, businesses should employ a top-down approach to environmental improvements. At minimum, executive mandates should be established that tie individual group performance evaluations to data center improvement initiatives. Many businesses have also experienced success with the introduction of a governance body that oversees optimization improvements. This governance group can be either dedicated personnel or comprised of critical members of the different support organizations. All service improvement plans and new projects are submitted to this board for review to ensure optimal and cost-effective platforms and processes are being adopted. It is also important to track the success of operational enhancement to ensure each organization is credited appropriately for its efforts in the improvement process.

Achieving Data Center Optimization

With a top-down data center improvement initiative in place, the development of business focused process improvements can begin. Of course, invariably the first question asked is "where to start?" To provide guidance in IT management process improvements, EMA has developed a maturity model that identifies key milestones in the advancement of service capabilities. Businesses are advised to determine which level their infrastructure most closely has attained and then systematically introduce process improvements that will enable the achievement of the next higher phase of development.

Figure 1: EMA Maturity Model

The individual phases in the EMA Maturity Model can be identified as follows:

- Level 1 (Reactive) – The starting point for most organizations where IT staff are principally trying to survive day-to-day crises. Management processes are triggered primarily by incidents and addressed with mostly manual activity supplemented by some scripting. Management tools tend to be device-specific, with few enterprise-class tools and little or no automation. Key elements of this phase include:
  - Use of element-centric management tools for siloed organizations
  - Management is reactive by incident
  - Security is limited to isolated point solutions – primarily firewalls and anti-virus software
  - IT purchases are driven by crises, rather than planned, integrated investments
  - Primary concerns are to increase efficiency and reduce costs

- Level 2 (Active) – Day-to-day operational issues are still paramount at this stage, but some processes are now documented and repeatable. Management tools are employed by whole departments and include some, though limited, automation. Business impact reporting may be available, but real-time alarming is limited to a few "green/red" status indicators. Key elements of this phase include:
  - Cross-organizational dialogue has improved, but integration of resources is still lacking
  - Service-level management remains primarily historical with some real-time linkages to performance and availability
  - Monitoring and management automation is minimal
  - Primary concerns are on improving access and control, security, and disaster recovery
- Level 3 (Proactive) – At this stage, a service organization becomes a fundamental and consistent interface to the broader business. Management processes are still primarily problem driven, but are more easily remediated with procedures in place for root cause identification. This constitutes a shift away from reactive incident management toward problem prevention. Management tools are integrated and automated across multiple managed environments and real-time alerts and other metrics are available to easily identify IT health and business value. Key elements of this phase include:
  - Management solutions are now chosen strategically, rather than reactively
  - Primary investments are in analytics and visualization to capture business impacts
  - Business priorities are consciously defined processes
  - Workflows are automated to capture best practices
  - Metrics are available to show business value and cost of IT services
  - Primary concerns are providing service levels to match business priorities
- Level 4 (Dynamic) – At the most mature stage in pragmatic data center management, day-to-day performance and availability issues are largely managed by automation, so that IT can focus on capturing business advantage and optimizing the infrastructure dynamically to suit shifting business conditions. Planning new services and improving quality of service is the focus rather than simply sustaining services or fixing breakages. Management tools provide detailed, environment data that enable real infrastructure decisions that will improve business agility and profitability, effectively closing the gap that exists today between physical infrastructure and the business layers it supports. Key elements of this phase include:
  - Automated solutions are in place for nearly all management functionality, including corrective actions, reports, dynamic service provisioning, and change management
  - Planning, implementation, and on-going support of IT resources crosses siloed organizations with common integrated tools and services
  - Resource management is fully focused on managing assets, capacity, and other investments as a dynamic part of IT's business portfolio

From the EMA Maturity Model, a prescriptive model can be mapped that identifies specific data center process improvements that should be initiated at each level to achieve optimization.

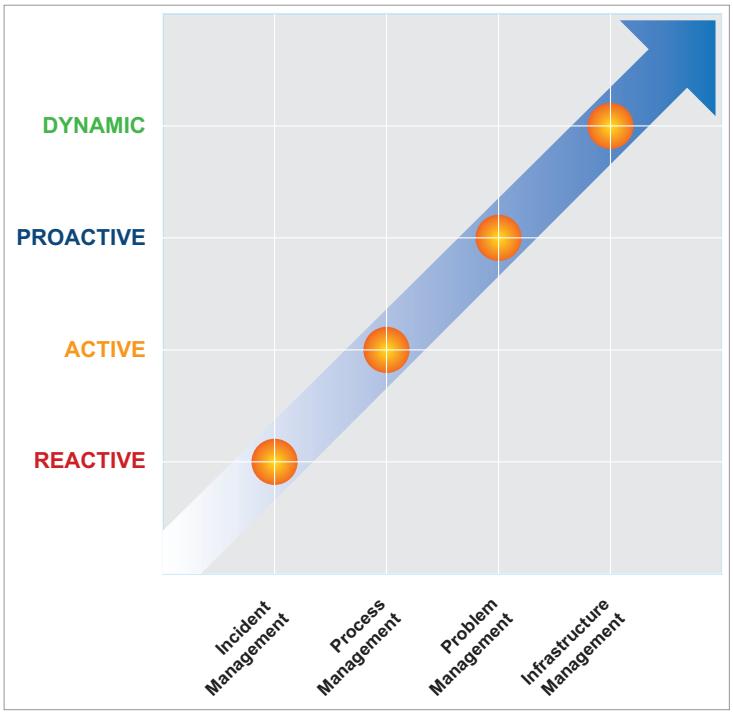

Figure 2: EMA Prescriptive Model for Data Center Optimization

Level 1 – Reactive: Incident Management

The first step to achieving data center management beyond purely reactionary responses to environment failures is to identify organizational IT requirements. Included should be expectations for IT service availability, time-to-resolution on IT equipment and environment failures, budget restrictions, and regulatory compliance considerations. If these are not already defined in Service Level Agreements (SLAs), they need to be established to clearly outline the management goals and to delineate roles and responsibilities across organizational structures. This will provide the basis against which operational efficiency will be measured at each subsequent phase of the data center maturation.

Existing physical infrastructure devices, along with their dependencies and performance, should then be identified and recorded in a centralized repository. This will be a "living" database of assets that must be updated as changes occur to ensure it contains an accurate depiction of all managed IT components and their capacities in the data center. Automated tools and manual methods may be employed both for the initial collection and on-going revisions. The health of all IT resources should be monitored from a central console to significantly reduce the time for problem identification.

Processes for regular system maintenance and problem remediation should be established and clearly documented with clearly outlined roles defined for both facilities and operational IT support staff. In the event of a system or environment failure, these standardized processes will provide an easily identified path to resolution that will shorten downtime and minimize impacts on business productivity. Standardized processes should be regularly revised by support and management personnel as

improvements are identified during problem resolutions. Management of the infrastructure components should be performed with a centralized remote access and control utility so that administrators can perform maintenance, installation, update, and remediation activities without having to physically access the data center.

A service desk also needs to be established at this early phase to traffic incoming customer requests and to log status and resolution of incidents. Requests should be prioritized with a higher weight of importance granted to requests that have the greatest affect on business performance or are causing the greatest disruption to IT productivity.

Professional services can be employed at this and subsequent phases to cost-effectively bring experience and expertise to specific process improvements, training, deployments, and problem remediation.

Level 2 – Active: Process Management

As the name implies, the key focus for this phase is the refining of management processes with the intent of improving overall service. To manage complex tasks, standardized processes should be organized into a series of connected steps called a "workflow." Workflows may contain tasks for multiple support personnel and may involve multiple support organizations. Similarly, a change management process needs to be introduced that documents, tracks, and authorizes new deployments, services, and updates. During the change management process, each department affected by the change should have the opportunity to provide input on what steps it will need to perform and how it will be affected by transition as well as to voice any concerns. An escalation process also needs to be defined, identifying a clear path to resolution on incidents that require management authorization or that do not conform to existing standardized processes and workflows.

Infrastructure control and access restrictions should also be expanded in this phase to include data center environmental conditions. In particular, this should include power consumption and temperature monitoring and reporting. Energy consumption is more accurately recorded in real-time from actual IT components or power distribution nodes that provide these details than by estimations based on system type and up-time, but both collections may need to be employed to get a complete picture of data center energy consumption. Temperature (or thermal) monitoring will identify "hot spots" in the environment that reduce cooling efficiency. By adjusting airflow or better distributing IT components, air conditioning units will not have to work as hard and will require significantly less power to operate.

In addition to power availability, other data center resources need to be managed to ensure availability for expansions and alterations. This includes the availability of physical space on either the floor or in existing racks, weight considerations, power and cooling, and network switch ports to support new hardware introductions.

Finally, with the pressures for IT availability 24/7, resources need the capability to access and control critical infrastructures from remote locations. The ability to remotely access, reboot and control servers and rack power strips will significantly reduce the Mean Time To Resolution (MTTR).

Level 3 – Proactive: Problem Management

At this level, management emphasis moves more towards the prevention of infrastructure failures and the strategic reduction of operational costs. From the processes and management resources established during the first two phases, detailed infrastructure health, status, and configuration data should be available for review and consolidated in a centralized repository. Analysis of this data is critical to

making informed decisions on infrastructure improvement. For instance, resolution of each failure incident should be accompanied by a root cause analysis that identifies the principal instigator of the problem. By resolving the root cause of problems, systemic failures are prevented from recurring, freeing up support staff to introduce additional improvements and meet new business IT requirements.

Analysis of change events is an important part of a root cause analysis and should also regularly be performed outside of failure events to proactively prevent incidents from occurring. Nearly every failure that occurs in an IT infrastructure is directly related to a change event that was either unanticipated or improperly implemented, so the automatic alarming on critical environment changes will enable the quick identification of potential problems before they become business impacting. To further prevent failure incidents from occurring, an impact analysis should be performed prior to the deployment of new IT services, and risk assessments should regularly be performed on managed systems to identify areas of concern. Automated tools can greatly simplify these evaluations by comparing IT components against established standards.

The granular thermal, power, and system usage details that have actively been collected can now be utilized to introduce energy reduction programs that will significantly reduce operational costs. Trend reports of individual IT components, in particular, will provide "quick wins" by identifying unused systems that can be decommissioned and servers that will be good targets for consolidation initiatives. Reporting on power usage effectiveness can also indicate opportunities for the introduction of automated power management solutions that reduce overall power draw during low-use periods. As energy reduction processes are introduced, infrastructure efficiency reports should be generated that track the progress and provide return on investment details of the cost reduction initiatives.

Capacity planning also becomes more proactive at this stage. Rather than identifying space and resource availability at the time a new service is to be implemented, anticipation of future growth should now be considered to achieve both near and long term expectations. This will ensure steps can be taken early to prevent reaching power and space limitations that may impede business growth. Additionally, capacity planning is essential for consolidation initiatives in determining resource availability for high-density systems. Visual modeling of the infrastructure will clarify data center configurations and further simplify capacity planning by providing an easily understood representation of resource and space availability.

Level 4 – Dynamic: Infrastructure Management

The goal of DCIM (and should be) a "unified" support infrastructure where multiple support teams utilize common resources and integrated processes to achieve business-focused goals. The business processes are enhanced by a "closed loop" critical infrastructure control system where the physical and virtual layers communicate in real-time. The greater this fusion of management services and infrastructure resources, the more cost effective, efficient, and effective the data center will be in meeting IT requirements.

To facilitate this, begin by enabling a holistic view of the entire support infrastructure so that events logged on disparate platforms can be easily compared to target the root cause of the problem. This monitoring should be integrated with configuration details of all supported IT components so that a single interface may be utilized for all intelligence gathering. Configuration Management Databases (CMDBs) provide a platform for consolidating system details from a variety of management and reporting tools. It is advised that the investment in any automated management solution be compatible

with a CMDB to facilitate this common information platform. Management processes must also be streamlined to correlate workflows across all facilities and IT support organizations. Not only will this more clearly delineate support rolls, it will also reduce incidents of service conflicts and duplicate efforts.

Holistic infrastructure reporting can be utilized by governance bodies to make informed decisions on the most effective data center configurations. For instance, rather than just implementing a consolidation project to support a single siloed organization, a centralized solution can be implemented that supports multiple organizations or consolidates resources from multiple physical locations. Change management and other governance boards will utilize integrated workflows and processes to develop implementation plans that minimize business risks. Cost factors should be considered in all change and deployment processes with an eye toward utilizing common resources for multiple purposes. Financial details for assets and maintenance expenses should be regularly reviewed to ensure all IT investments are serving business interests rather than the other way around.

Implementing Tools for Success

Essential to the successful optimization of data center efficiency is the availability of automated tools for monitoring and managing the infrastructure. Today's dynamic data centers are simply far too complex to manage effectively through purely manual or disparate processes. Fortunately, automated solutions are available that can simplify complex data center infrastructure challenges by providing granular details about the environment health and status, sustain secure access and control, and facilitate end-to-end process improvements. With a fully integrated automated monitoring solution in place, organizations will have a true, single-pane, contextualized, real-time view of both the physical and logical data center infrastructure. Emerson Network Power, in particular, offers a wide selection of enterprise-class solutions for enabling informed decision making and automated enhancements that have been vetted for quality in production environments. Included in its portfolio of solutions are several enterprise-class products designed to align IT and facilities organizations:

- **Liebert SiteScan™/Liebert Nform™** – Designed specifically for monitoring and controlling cooling, power, UPS and other data center facility equipment. Features include real-time monitoring, data analysis and trend reporting, and event management.
- **Avocent® DSView™ 3 Management Software** – Provides data centers with secure, centralized management for physical and virtual IT assets. When used in conjunction with KVM appliances, serial console appliances, service processor gateways and rack PDUs, the hardware and software combine to allow IT administrators to remotely access, monitor and control devices on multiple platforms at numerous locations.
- **Avocent DSView Software Power Manager Plug-in** – Adds power monitoring and reporting capability to the access and control functions of DSView 3 software.
- **Avocent Data Center Planner™** – Creates a visual representation of the data center with an accurate depiction of the type and location of servers, racks, and other IT components. Planned changes and additions can be modeled to identify exactly how the alteration will affect the rest of the IT ecosystem and also to identify optimal locations and configurations of hardware platforms.
- **Aperture™ Infrastructure Process Manager** – Establishes control over people and processes within the data center and enables the introduction of standardized best practices that ensure consistency in the infrastructure. Achieves process improvements with equipment installs, moves and decommissions, and minimizes the impact of changes to improve overall data center performance.

- **Aperture Configuration Manager** – Provides analytics on the IT and facility management of the equipment, space, power, cooling, and port connectivity. Offers a visual representation of data center resources and consolidates the collection of granular configuration details.
- **Aperture Capacity Manager** – Analyzes the current data center state, consumption trends, and historical usage patterns to enable proactive capacity and predictive planning. Project pipeline management provides clarity around how and when infrastructures will be used and enables the careful budgeting of data center resources.
- **Aperture Integrated Resource Manager** – Collects real-time utilization data from IT and facility equipment to enable a holistic view of the support stack. The solution assigns a risk-adjusted value that represents the actual load on managed resources. This provides actionable operational information that helps IT successfully analyze and manage data center resources, maximize utilization, and improve process efficiency.
- **Aperture Integration Manager** – Integrates the management of IT systems by consolidating and correlating technical details and resource administration across the infrastructure. Enables service-centric performance optimization with support from best practices such as the Information Technology Infrastructure Library (ITIL).

Implementation of tools should coincide with the deployment of new services for data center improvements. Emerson's modular approach to infrastructure management is particularly helpful here as it allows enterprises to invest in solutions when they have reached the data center maturity appropriate for their introduction. The chart below identifies how key features of the Emerson packages map into the EMA data center optimization prescriptive model:

	Level 1 - Reactive: Incident Management	Level 2 - Active: Process Management	Level 3 - Proactive: Problem Management	Level 4 - Dynamic: Infrastructure Management
Liebert SiteScan / Liebert Nform	• Enable centralized monitoring and control of IT components • Event management	• Monitor environmental conditions in real-time	• Perform trend reporting of environmental components • Facilitate data analysis	
Avocent DSView 3 Software / DSView software Power Manager plug-in	• Facilitate remote management of supported devices	• Schedule tasks, updates, and file loads	• Automate software and hardware level power control • Power monitoring and reporting	
Aperture Infrastructure Process Manager	• Prioritize requests to better meet organizational requirements • Customize status reports and email alerts to improve clarity	• Establish escalation processes • Introduce workflows to coordinate activities	• Correlate workflows for better organization and to reduce duplicate efforts • Identify and decommission unused systems	

(Table continued on next page.)

	Level 1 - Reactive: Incident Management	Level 2 - Active: Process Management	Level 3 - Proactive: Problem Management	Level 4 - Dynamic: Infrastructure Management
Aperture Configuration Manager	• Automate configuration management processes	• Report power consumption and cooling details • Standardize workflow processes for changes and deployments	• Perform impact analysis • Visual management of data center resources • Enforce standard utilization metrics and recapture underutilized resources	• CMDB integration • Integrate management processes • Provide details for finance and maintenance contracts
Aperture Capacity Manager		• Manage space availability • Oversee network switch port availability	• Proactive capacity planning	• Balance inventory resources to meet business demands
Avocent Data Center Planner		• Track infrastructure assets and configuration	• Enable visual modeling of the data center infrastructure	• Plan data center implementations with predictive analysis
Aperture Integrated Resource Manager			• Provide risk assessments on managed systems • Identify power usage effectiveness and infrastructure efficiency	• Collect and analyze data from disparate IT components for a holistic view of the data center
Aperture Integration Manager			• Enable cross-platform visibility into the infrastructure	• Enable service-centric IT management decisions • Organize processes between operations and facilities for improved communications

Figure 3: Emerson Solution Suites mapped into EMA's Prescriptive Model for Data Center Optimization

With the right management tools in place, enterprises can expect broad improvements in performance, reliability, and cost effectiveness achievable commiserate to the level of maturity of the data center support infrastructure. Enterprises will be able to support higher densities of equipment and services while reducing the overall cost of operations. Consolidation initiatives will minimize capital expenditures, energy reductions will diminish operational expenses, and streamlined processes will require less staff to achieve business goals. Holistic data center views and reports will enable IT managers to make strategic decisions for improving overall service and to identify accurate and complete cost details of projects prior to their implementation. Dynamic data center optimization enables business IT agility, positioning enterprises to compete effectively in the marketplace and ensuring cost-effectiveness that will boost profitability.

EMA Perspective

Interest in DCIM practices has increased substantially in recent years. This should be no surprise as the introduction of more centralized, business-focused IT services has brought organizations to the realization that data centers are, in effect, an entire eco-system – with interdependencies that run across systems, racks, networks, power distribution, environmental controls, and many other individual and unique elements. Alterations to any one of these components will directly affect the others in a complex chain-reaction that is impossible to trace without sophisticated processes and automated tools.

Although there is currently no "magic bullet" for completely addressing all data center management challenges from a single automated package, a solution that focuses on optimizing an exceptionally broad number of processes and management services will best prepare enterprises for meeting the challenges of the future. The key is introducing integrated solutions that can address multiple layers of DCIM processes and provide holistic management views and operations. Emerson Network Power is clearly committed to achieving the goal of providing a complete end-to-end DCIM solution, and its family of product suites offers an extensible solution for addressing today's critical DCIM challenges and building on those capabilities to meet expanding requirements as IT infrastructures mature and evolve.

About Emerson

Emerson Network Power, a business of Emerson (NYSE:EMR), is a global leader in enabling *Business-Critical Continuity*™ from grid to chip for telecommunication networks, data centers, health care, and industrial facilities. Emerson Network Power provides innovative solutions and expertise in areas including AC and DC power and precision cooling systems, embedded computing and power, integrated racks and enclosures, power switching and controls, monitoring, and connectivity. All solutions are supported globally by local Emerson Network Power service technicians. Aperture and Avocent solutions from Emerson Network Power simplify data center infrastructure management by maximizing computing capacity and lowering costs while enabling the data center to operate at peak performance. For more information, visit www.Aperture.com, www.Avocent.com, or www.EmersonNetworkPower.com.

About Enterprise Management Associates, Inc.

Founded in 1996, Enterprise Management Associates (EMA) is a leading industry analyst firm that provides deep insight across the full spectrum of IT and data management technologies. EMA analysts leverage a unique combination of practical experience, insight into industry best practices, and in-depth knowledge of current and planned vendor solutions to help its clients achieve their goals. Learn more about EMA research, analysis, and consulting services for enterprise IT professionals, lines of business users, and IT vendors at www.enterprisemanagement.com or follow EMA on Twitter.

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