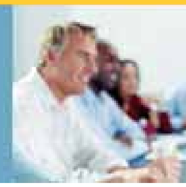
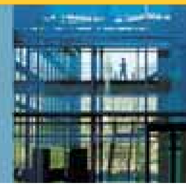
white paper Data Centers





Integrated Building Management Systems in Data Centers

Learn how these mission-critical facilities can be optimized using an integrated Building Management System and an energy efficient approach.

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I. Executive Summary

As the data center market expands, power and cooling have become the primary focus for data center managers and senior executives. The volume of online video, commerce, gaming and regulatory compliance requirements continues to rise, increasing the need for more data storage. The high demand for data centers identifies them as a critical asset for any business, whether the enterprise operates its own data center or uses colocation facilities.

But how do data center managers cope with this IT equipment? How do they deal with the heat generated from these servers? How do they manage physical security for the facility? How do they boost energy efficiency? These questions must be explored and answered to prove reliability for IT and facility managers, senior executives and all the customers of the data center.

The trend towards high density data centers, which require more energy and generate more heat, means that most existing data centers will need to implement new power and cooling solutions. Driving these solutions is the recognition that there are already cooling deficits in nearly every data center. Escalating operating expenses for power and cooling now surpass the costs to purchase servers.

While data centers can run as part of an office building, they consume 25 to 50 times as much power as an average office. Estimates are that between 40 to 50 percent of all data center power is devoted to the HVAC and other cooling systems. Such a hefty number suggests some opportunities for energy efficiency. These numbers were developed from benchmarking efforts in large data centers. Now public and private examination is converging on data center energy efficiency because of the total power consumption.

A Building Management System that operates on open protocols over the IP network functions as an intelligent tool that monitors and controls every aspect of the data center. By understanding the mechanical, security and electrical components in a data center, a data center or facility manager can determine which best practices to implement that will protect IT assets and minimize costs and downtime in this environment.

Building Management Systems take advantage of centralized monitoring and control to manage data center facilities targeting the entire site all the way down to the server rack. In fact, the BMS server is routinely installed inside a rack in the data center that it monitors because it depends on this controlled environment.

An integrated Building Management System addresses and serves the complexity, scalability and flexibility required for data centers. Yet integrated control and monitoring delivers more than lower operating costs. The BMS extends the life of the HVAC system components and supports the overall infrastructure, as well as the IT equipment that operates in the data center.

Together, an integrated Network Management System and BMS proactively monitor data center operations delivering high-reliability. The goal of this paper is to examine these systems and offer some energy-efficient techniques to assure that capital expenditures in the facility and equipment follow an optimal projected lifecycle.

II. Introduction

Investment in data centers is growing rapidly with the global market for expansion, renovation and relocation valued at about $25 billion last year. Worldwide, over 27,000 data centers operate and plans exist to develop more than 10,000 in the next few years. As these mission-critical facilities are built, new servers are quickly filling available floor space. Data centers operate as a critical asset for any enterprise regardless of size. The features of this dynamic asset – like scalability and flexibility – are complex, making data centers challenging to manage.

How do data center managers cope with the new IT equipment in these facilities? How is the intensifying heat generated from these servers handled? How do they manage physical security for the facility? Once these questions are answered, what about boosting energy efficiency in data center operations? Many ideas have been studied but doubts about how they apply to an existing data center and how to implement these solutions have deferred their adoption. IT and facilities managers must work together to determine the best solutions for their data centers today.

The trend towards high density data centers, which require more energy and generate more heat, means that most existing data centers will need to implement new power and cooling solutions. Driving these solutions is the recognition that there are already cooling deficits in nearly every data center. Escalating operating expenses for power and cooling now surpass the costs to purchase servers.

The best way to manage these environments is to understand all of the systems in a data center. Knowledge about the Building Management System (BMS) and the Network Management System (NMS) offers insight to problem detection and eases troubleshooting. Together, an integrated NMS and BMS proactively monitor data center operations delivering high-reliability.

III. Building Management Systems — the Environment

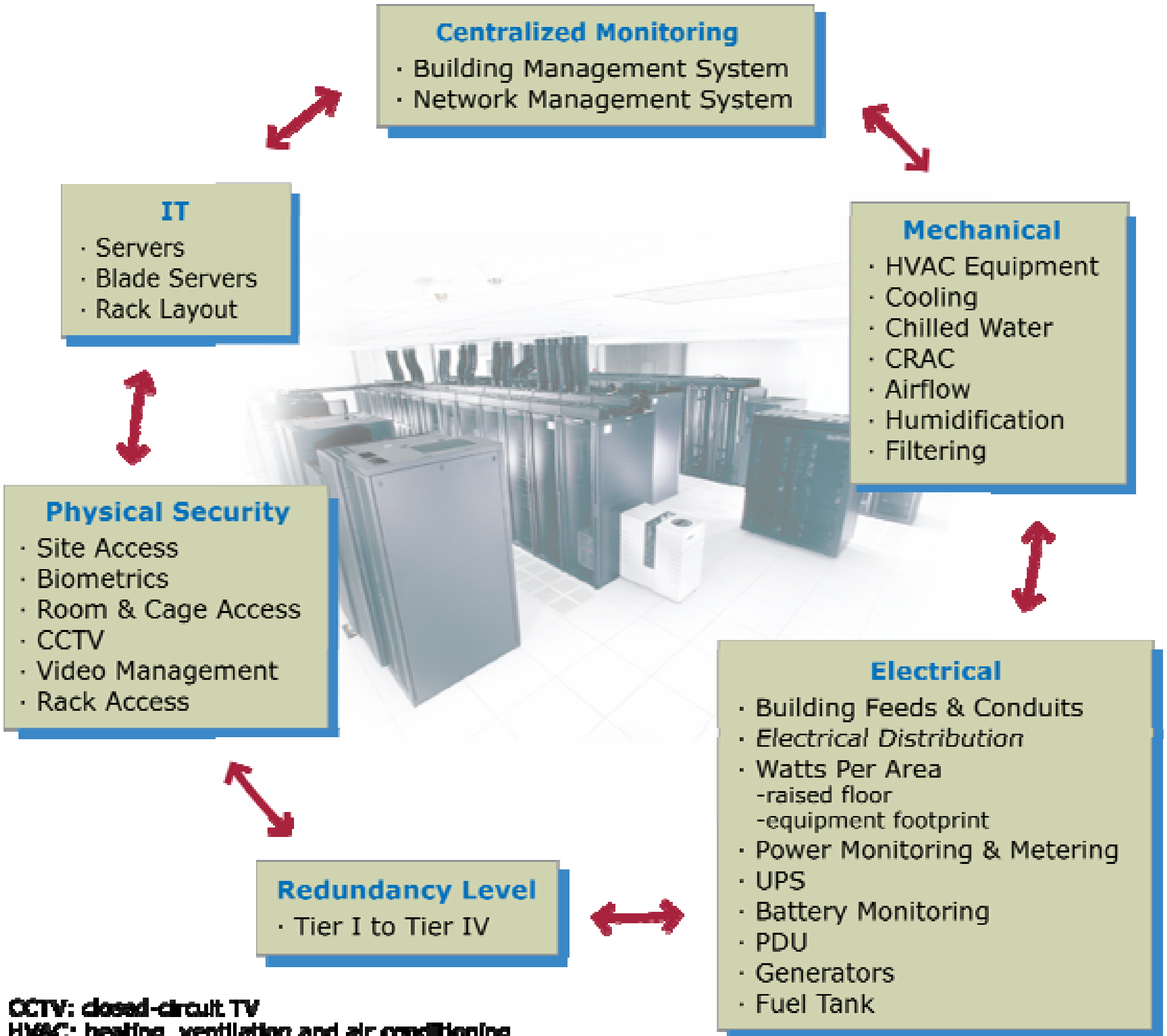
Whether running an enterprise data center or using co-located facilities, the reputation of the site depends on availability. Data centers operate on a dedicated 24/7 schedule to perform financial, business process, supply-chain, and customer-relationship applications. As the volume of online video, commerce, gaming and regulatory compliance requirements rise, more data storage is needed. A colocation site can be the primary data center for an enterprise or it may function as a backup site for disaster planning. In smaller enterprises, colocation might suit all of their data center needs.

Any service interruptions impact data center availability and add cost. Extra time for recovery is also required no matter how effective disaster planning might be. Again, this inhibits the efficiency from both an IT and a facilities point of view. Advanced monitoring and control of critical data center components supports complete facility management. The typical infrastructure includes:

- IT — Server Racks
- CRAC (Computer Room Air Conditioning) Units
- Chilled Water
- Physical Security
- Server Rack Security
- Fire, Water, Smoke & Life Safety
- UPS (Uninterruptible Power Supply)
- Diesel Generators
- PDU (Power Distribution Units)

Conditions like power, airflow, ambient and server rack temperatures, humidity, physical security, and fire, water, smoke and life safety assurance are controlled and monitored with a Building Management System (BMS). The BMS alerts facility managers when critical parameters approach or cross control limits. The BMS operates on a common Ethernet over IP network using standard IT protocols like TCP/IP and SNMP – Simple Network Management Protocol. The power, cooling, humidity, air filtering, water, access control, video surveillance, rack access and security are key components of data center operations as shown in **Figure 1**.

Figure 1. Data Center Components



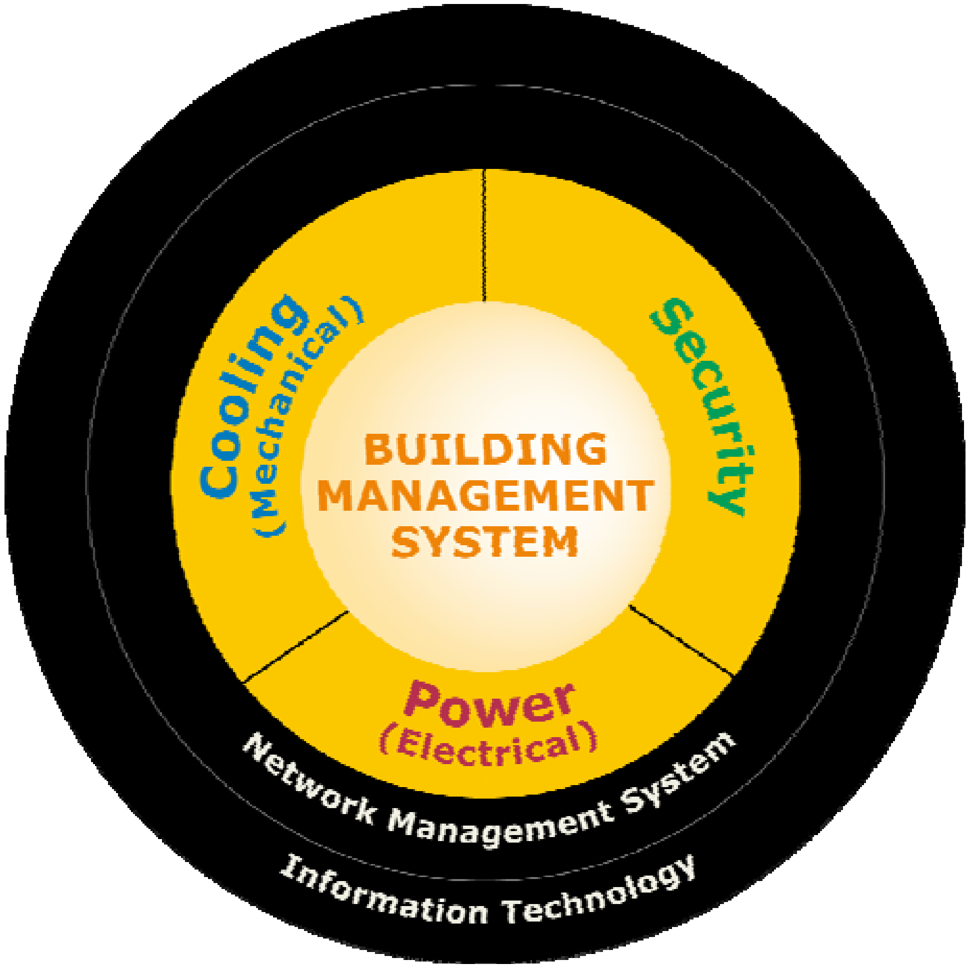
CCTV: closed-circuit TV
HVAC: heating, ventilation and air conditioning
CRAC: computer room air conditioning
UPS: uninterruptible power supply
PDU: power distribution unit

CONTROL AND MONITORING IN DATA CENTERS

The growth and high demand for data centers supports a need for best practices including improving efficiencies and lowering costs. Deploying an integrated BMS fulfills these goals. Some data centers are purpose-built while others are part of an office building and the size of a data center ranges from thousands of servers down to a few.

Most data centers include redundant systems so that availability is preserved in the event of system failures or maintenance. These redundant components might include generators, the UPS and/or multiple sources from the power grid. At the highest levels of redundancy, complete maintenance can be performed during operations without system failures. The model of how the data center components integrate together is shown in **Figure 2**.

Figure 2. How the Components Integrate



COOLING – (MECHANICAL)

Air-Handling Units

The Air-Handling Unit (AHU) introduces cool air and exhausts hot air from a data center. Inside the AHU, there are typically fans, motors, filters, humidifiers, and a cooling coil. The large box-like AHUs can manage air and control the temperature, humidity and air-filtering process for outside air.

Filtering

Because the majority of data center operators believe that particulate matter in outside air will harm IT equipment, they have shied away from bringing cooler outside air into the data center. Yet recent work by the Lawrence Berkeley National Laboratory showed that if filtering is used correctly, then the filters are effective. They benchmarked a number of large sites that use filtering as a part of their solution.

Computer Room Air Conditioning (CRAC)

Cooling components like Computer Room Air Conditioning (CRAC) units are usually installed on the perimeter of a data center. CRACs cool air and push it through the raised floor to the server racks. Humidification which takes place in the CRAC is important because IT and infrastructure equipment could be damaged by static electricity generated when the humidity level is too low.

Chilled Water Systems

In larger data centers to cool the air, CRACs are combined with Chilled Water systems which are at the center of a centralized air conditioning system. Chillers move the heat to a refrigerant to cool the water pushed from the AHUs. Then a condenser cools this heated refrigerant with cooled water. Finally, this heated cooling water passes to a cooling tower and the heat is released to the outside atmosphere with fans.

The Building Management Systems can maintain temperature, humidity and airflow within limits for peak efficiency by managing and controlling these components. In fact, the BMS server is routinely installed inside a rack in the data center that it monitors because it depends on this controlled environment. Beyond the control gained with the BMS, all HVAC points are monitored using data from the control process. Sensor data on temperature, humidity and airflow is logged for reporting and alarms are sent when thresholds are exceeded. Integrated control and monitoring with a BMS delivers more than lower operating costs. The BMS extends the life of the HVAC system components and supports the overall infrastructure, as well as the IT equipment that runs in the data center.

SECURITY

Access Control & Monitoring

Control and monitoring for security applies to both the host building site and the data center. Access to buildings, gates, doors, colocation cages and server racks is restricted for unauthorized users. Biometric, card, and keypad access can offer facility managers the flexibility to control these access points. Some type of biometric authentication is used in nearly half of large data centers and might incorporate a fingerprint, hand measurement, retina or iris scan, or face pattern.

Access can be granted or denied by assigning specific staff to groups or specifying role-based groups, setting schedules, and using temporary access codes. Lost cards, the need for access override and other reasons can be addressed once the biometric database is built. This makes the access control process cost-effective to manage.

CCTV & Video Surveillance

Data centers require solutions that blend live surveillance and captured video. Security with video surveillance was once a passive system of observing entry points and hallways with Closed-circuit TV (CCTV). Now video surveillance can include live video and captured video images. These solutions help to manage large, co-located or remote sites. Using a Digital Video Management System (DVMS) with Digital Video Recorders (DVRs) enables enhanced video applications and replaces the need to manage CDs or videotapes that require more labor and incidental expense. Digital formats let data center operators achieve surveillance objectives like:

- Instant retrieval and search of video based on time, date, camera or viewing area, especially important for legal matters.
- Motion near a camera activates a video capture that records pre- and post-event video for a given period.
- Activation of alarms are based on motion across a camera field of view so live video feeds can be viewed.
- Digital video is being transmitted over the IP network so a Network Operations Center (NOC) or central management location can verify activities.

Hybrid surveillance solutions mix existing analog and newer digital or IP cameras. The DVMS allows prompt receipt of video and rapid or automatic response to prevent losses. Video solutions make it possible to observe the entire building site of the data center right down to server racks.

Security solutions exist to monitor the status of cameras in the data center and link the captured video to video analysis software and storage services based on servers. This powerful component can be integrated with the BMS and the NMS with SNMP alarming services. So video images can be taken when a server rack is accessed with a card and unauthorized intruders are tracked and alarms are sent to each of these systems. One solution joins multiple DVRs into a rack enclosure with integrated cooling and UPS components to secure the DVMS and maintain optimal cooling and availability.

Best practices in access control and video surveillance involve monitoring and logging entry events. When events are monitored, the data is stored for reports and historical reference. Who entered and at what time? How many attempts at access occurred? Is the door secure after entry? Has the door, cage or rack been left open for an extended period of time? These questions are answered via audit trails which are important in large data centers and in colocation facilities where many customers have access to the building.

Fire, Water, Smoke & Life Safety

Building control and monitoring solutions include sensors for fire, smoke, carbon monoxide, water leaks, and other elements that could contribute to safety emergencies or loss. If these sensors operate within an existing system then these sensors can be integrated into the BMS.

POWER – (ELECTRICAL)

Power Monitoring

Monitoring the capacity, availability, maintainability and condition of power is vital for reliability. Power can be interrupted by circuit and alarm panel failures within the data center – where typical power issues arise. Outside of the data center, catastrophic weather conditions and high demand that burdens power grids can also have an effect. Power outages trigger switchover to backup power. When backup power is enabled, limited time exists before battery power fails and data center temperatures exceed set points. Monitoring power saves facility and IT managers from downtime. Sensors on static switch transfers monitor reliability to the data center's critical loads.

To ensure availability, diesel generators can be monitored which verifies that operators have started, operated, and tested generators as scheduled. During an actual power failure, sensors provide parameters such as start time, power output, switch status, and temperature, so that data center employees can be confident about generator output. All of this power monitoring data can be integrated into the BMS.

Power Metering

As data centers expand floor space and integrate high density servers, power use and intensity increases along with operating costs. Metering allows data centers to perform energy management from the utility power source and perform predictive maintenance for power loads, especially when meters are integrated into the building management system. The result validates savings with lowered operating costs for the data center and enhanced power quality control.

Battery Monitoring

Battery monitoring ensures that backup power, normally the UPS – Uninterruptible Power Supply – for power systems are ready to support equipment when power fails. Too high or too low ambient temperatures decrease battery life and reliability because chemical reactions inside the cells are altered by these extremes. Real-time monitoring of cell-by-cell battery conditions measures and logs individual cell voltage, cell resistance, string current, and temperature. Early warnings of approaching thresholds send alarms to a workstation. This proactive approach increases efficiencies for a data center's battery replacement policy.

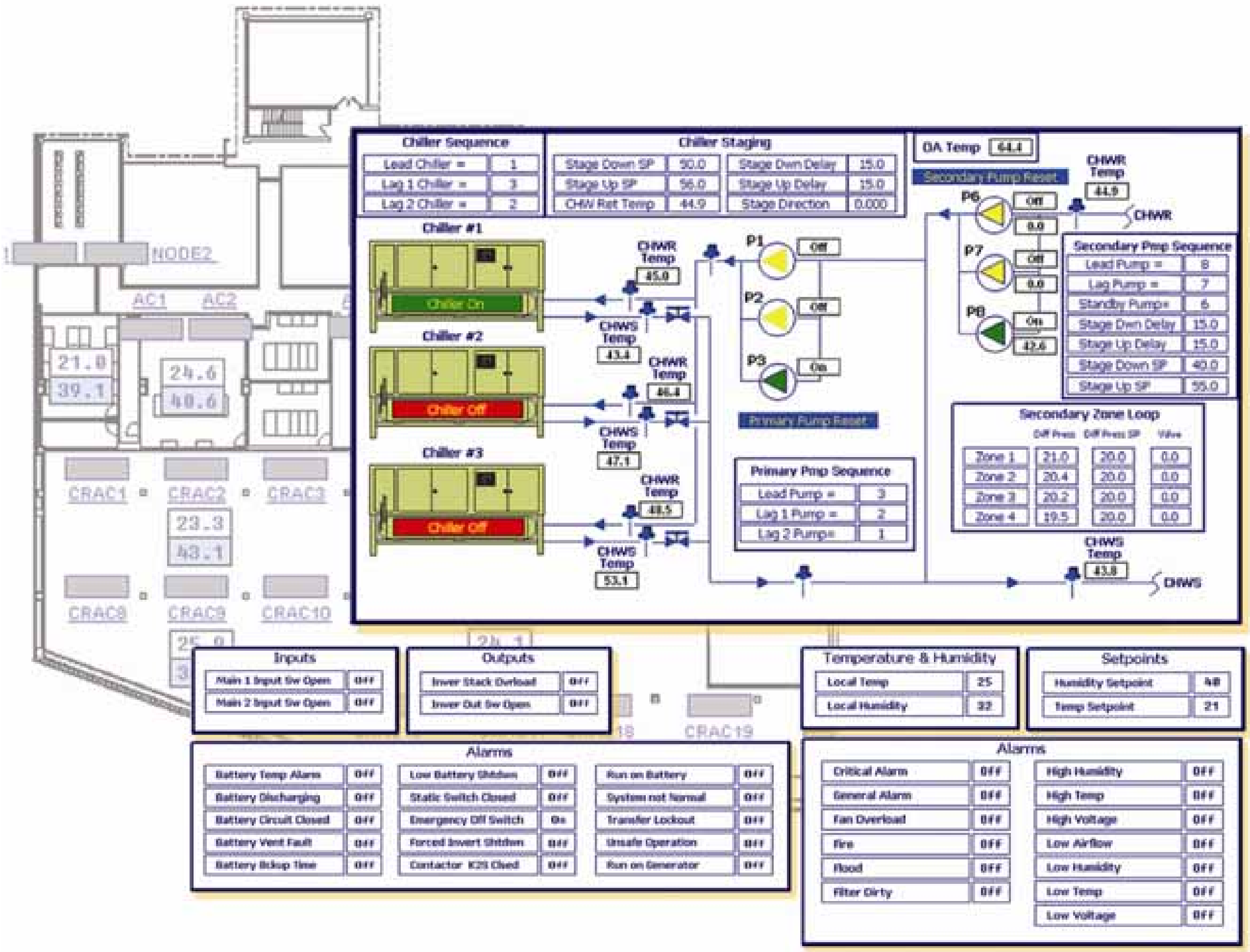
Fuel Tank Monitoring

Data centers with generators rely on diesel storage tanks to power these backup generators. Because fuel leaks from these tanks create environmental pollution, sensors to detect leaks permit early detection and alarming. Flip alarming and detection allows investigation of the nature of the leak and environmental authorities can be notified as required by law.

THE BUILDING MANAGEMENT SYSTEM AT WORK

Consider that all of the data from a Building Management System provides data center managers with real-time and historical context to think about the entire spectrum of incidents and then root out problems quickly. All or any of the data is potentially accessible from anywhere at anytime to authorized users via a browser on a workstation, a PDA, an email or a mobile phone. The benefits of integration are evident when one can control these systems, monitor their operation, and correlate which seemingly isolated conditions may influence others. An example of how the BMS views the status of components is shown in **Figure 3.**

Figure 3. The Building Management System at Work



When a water leak alarm is sent soon after an extended “door open” alarm, maybe someone has propped the door open on a rainy day. Video images could confirm that a broken water pipe or roof leak is not the cause. Perhaps a report shows that the generator has not been operated or tested as scheduled, despite access records that show the data center operators have been on site. Connecting these facts leads to cost savings because data center managers can manage staff better, reduce staff when necessary, and excel at alarm response by understanding root causes.

IV. Energy Efficiency in the Data Center

While data centers can run as part of an office building, they consume 25 to 50 times as much power as an average office. This presents a conflict when office spaces are re-purposed into data centers because office cooling requirements dramatically differ from a data center's need for increased cooling capacity. Estimates are that between 40 to 50 percent of all data center power is devoted to the HVAC and other cooling systems. Such a hefty number suggests some opportunities for energy efficiency.

Because it is hard to optimize and manage cooling, the average data center uses 2.6 times more cooling capacity than required for the heat load, according to the Uptime Institute.[3] One data center they benchmarked had about 25 percent hot spots despite running ten times more cooling capacity than needed. Server reliability declines by 50 percent for every 18° F (7.8° C) above 70° F (21° C). In fact, just 28 percent of chilled air actually reaches the server racks – the remaining 72 percent totally bypasses the servers. More than half of this 72 percent escapes from holes and conduits for cabling and pipes in the raised floor. Another 14 percent of this 72 percent number leaks from perforated floor tiles that do not face the hot racks. Sometimes, too many perforated tiles are being used on the floor, defeating the goal of focusing the cool air. Additionally, about 10 percent of cooling equipment fails without notifying data center operators. Are these cooling failures due to poor maintenance of these systems?

These numbers were developed from benchmarking efforts in large data centers. Now further investigation and focus is converging on data center energy efficiency because of the amount of total power consumed in these facilities. The US Environmental Protection Agency (EPA) was tasked by the US Congress to study and suggest how to improve efficiency in December 2006. In July 2007, after working with public and industry groups like newly established The Green Grid, guidelines will be released. The Green Grid — www.thegreengrid.org — includes companies like chip and hardware manufacturers, data center component vendors, software companies, data center consultants and colocation site developers. Their goal is to develop energy efficiency metrics and best practices for the data center industry.

The Technical Committee 9.9 of the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) focuses on mission-critical facilities and publishes handbooks and guidelines to help tackle cooling issues in data centers.

SOLUTIONS

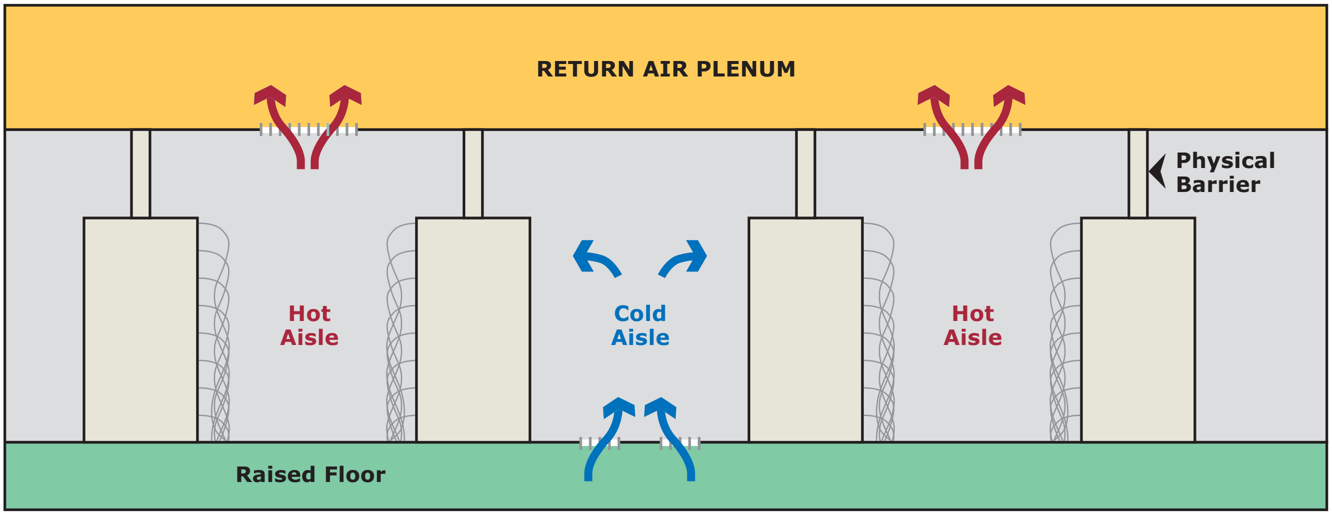
Nearly all data centers have "hot spots" where temperatures exceed limits. Server designs have responded to higher densities by adjusting the placement of components to reduce heat. Data center managers used to combat hot spots by adding more cooling equipment or they shifted servers into larger data centers.

But it is hard to decipher the cooling equation when you factor in stretched budgets and increased power costs. A number of methods can be applied to control airflow by introducing cool air and exhausting heat from the data center. These solutions are discussed below.

Rack-Level

Configuring server racks using a Hot-Aisle/Cool-Aisle design brings cool air into the front of the server rack from the raised floor and exhausts hot air from the back of the rack up to the ceiling plenum. The hot air is then vented from the plenum – above the drop ceiling – to the outside, as shown in **Figure 4**. In this case, mixing of hot and cool air is eliminated so efficiency of the HVAC system is improved and hot spots are decreased.

Figure 4. Hot-Aisle/Cool-Aisle Design



To control airflow at the rack, filler or blanking panels are recommended. These panels cover vertical spaces in the rack without servers or switches and ensure that hot air is not recycled into the front or cool side of the server rack. Without blanking panels, hot air that is discharged increases the intake temperature of a server by up to 15° F (9.4° C). An additional way to promote proper airflow at the rack is to install cable pass-thru brush strips that allow cables to pass from the front to the rear of the server rack. These strips also help to block hot air from the cool side of the enclosure or rack.

Supplying cooling within the row of server racks is an added solution. In-row cooling towers are built inside a full- or half-rack cabinet enclosure and these can be installed on one or both sides of a rack. When cooling is done adjacent to the rack, it adds power to server racks lifting wattage per square foot and helping the perimeter-based CRACs struggling to cool the entire data center.

What about adding cooling capacity by grouping two adjoining rows of racks under a single roof or hood with a single exhaust? How about using physical barriers to separate the aisles – hot from the cool? These options carry the concept of hot aisle/cold aisle to a new level by containing hot air and then rejecting it from specific rows.

When moving away from the racks, it is important to concentrate on how to improve the use of existing cooling systems that effect total airflows in the data center.

Air-side Economizers

For temperate locations, there are many months when the air outside of the building where the data center operates is cooler. In fact, the range of three to nine months per year is talked about when it makes sense to pull cold outside air into the hot data center. Of course, cooler night time air could be used for this purpose in many climates. This concept is called “free cooling” and the reasons why this has not been fully adopted includes a fear that outside air has too much particulate matter in it that would harm IT equipment. Other experts conclude that free cooling saves power though the air must be filtered and sometimes humidified.

Just as air-side economizing can bring cool outside air into the data center, waste heat from the data center can be used during the cooler months of the year in other areas of a building. For example, offices, lobbies and conference rooms adjoining a data center can be warmed by pushing hot air from the data center into these spaces. Most air-side economizer solutions require additional sensors and controls but the very low operating costs show that there is clearly more room for savings.

Water-side Economizers

Intel IT which runs Intel’s data centers recently implemented water-side economizers in two of its sites. For this solution, they initially thought that air-side economizers would work best. The final decision was to implement water-side economizers because of the evaporative cooling effect that reduces the load on the chillers and substantially cuts power requirements. Intel estimates the savings at about US $150,000 per year and an 85 percent improvement forecasted for their first site. For the other, they calculate a 104 percent improvement.

Air Management

When Variable Speed Drives (VSDs) are merged with high-efficiency chillers, pumps and cooling towers, the result of rightsizing can dramatically improve efficiency, according to the Lawrence Berkeley National Laboratory. An excellent technique to retain the complex airflows in the data center is to add the proper ductwork so that hot air from the server racks is directed back via a return air duct to the CRAC unit. The effect pushes hot air directly to the CRAC which helps it run more efficiently.

Humidification

It seems strange but tight humidity control actually makes a data center less efficient. In benchmarking performed by the American Council for an Energy Efficiency Economy (ACEEE), they mention that at the same time, humidifying and de-humidifying occurs in many data centers. This is not efficient. In this case, it could make sense to use a make-up AHU that does all of the humidification centrally, rather than allowing each CRAC to monitor and provide humidity. Calibration of humidity levels and sources is an easy solution leading to energy efficiency.

V. Network Management Systems — the IT Infrastructure

Just as the BMS provides data about the facility, the Network Management System (NMS) alerts data center managers about problems with the network. As the facilities of a data center support an IP infrastructure, software to configure and manage network hardware monitors performance, throughput, configuration, fail-over paths, uptime, etc. Vendors like Hewlett-Packard (OpenView), IBM/Tivoli (Netview), and Computer Associates (Unicenter) offer these software solutions.

NMS software generally runs in a Network Operations Center (NOC), which is the control center facility for infrastructure, equipment and people. NOCs are often built to operate across a group of enterprise data centers and may include colocation facilities. Some colocation providers run regional NOCs. Network connections mapped with the NMS enable the NOC to monitor cables, paths and routing devices and the supporting facility.

CENTRALIZED MONITORING

When alarms are sent from the BMS or the NMS, data center operators respond to incidents on a reactive basis. A proactive approach allows the NOC to seek out trends and correlations in network data that can point to future trouble. Software and hardware tools poll network devices for data, so that staff can analyze performance information. Since the NOC also monitors the network at remote sites, the use of SNMP alarming notifies the NOC about facility-based alarms posing operational threats.

Data centers have experts who focus on HVAC equipment, power systems, security and access devices, fire, smoke, water and life safety. Instead of replicating these functions, centralized monitoring helps this expert team assess alarm conditions and assign workers to remedy problems. A single data center operator can manage hundreds or even thousands of incidents. In some cases, the BMS can help to fix a problem like restarting a compressor or adjusting a temperature control from the NOC. If enough quantitative and qualitative data is logged, the operator can view reports of past incidents and learn valuable lessons.

If virtualized data is scattered across multiple data center sites, the BMS is flexible enough to be configured to send specific alarm conditions via SNMP to multiple centralized locations for coordination or automated escalations. As a result, the integration of BMS alarms sent to the NMS provides efficient use of each of these systems.

VI. Conclusion

The dynamic and complex environment of a data center makes it a challenge to manage. Data centers are rapidly expanding floor space and more are being built to meet high demand. A focus on the environment where these mission-critical servers operate is key because the data center is a critical asset for any business, whether it is run on-site or in colocation facilities. Since data centers must be flexible, a facility's normal lifecycle does not match the lifecycle of the servers running inside it. About every three years, servers are replaced as IT functionality increases. Yet the life span of a facility is ten to fifteen years.

How can this disparity be handled? The answer is to integrate the components of a data center into a Building Management System. The BMS allows facility managers to team with IT, thus bridging a traditional gap between these two functions. They can leverage expanding investments in high density IT equipment and facility infrastructures by working together to reduce costs and increase reliability. Optimal tuning of both the building and the data center can efficiently reduce downtime risk. This tuning should include strict maintenance schedules that ensure that all necessary tasks are completed on time.

Adopting standards lets every data center select products from vendors that meet these demands. Using a BMS with devices that operate on industry-standard protocols like BACnet and LonWorks assists data centers when it is time to expand. Utilizing the IP backbone coordinates the activities of the BMS with the NMS to gain an understanding of related alarm incidents leading to rapid problem resolution. A byproduct of this coordination is feedback that promotes better planning, smarter procurement strategies and unanticipated ways to lower operating costs.

Building Management Systems take advantage of centralized monitoring and control to manage data center facilities targeting the entire site all the way down to the server rack. The integrated results encompass the complexity, scalability and flexibility required for data centers.

About TAC

TAC is a leading provider of building automation solutions based on Open Integrated Systems for Building IT. TAC's mission is to provide added value through building environment services for indoor climate, security and use of energy, delivered with advanced technology to end-users and property owners around the world. With over 80 years of experience in the HVAC, building automation and security arenas, TAC employs more than 5,000 people worldwide, with partners and branches in 80 countries. TAC's parent company, Schneider Electric, is the world leader in automation and electricity management, with 112,000 employees and operations in 190 countries.

WP-DC-INTGBMS-US
May 2007

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