Environmental Data Center Management and Monitoring

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Introduction

When data center managers think of environmental management and monitoring they typically think of temperature sensors, and perhaps humidity sensors but, where should they be placed? Though temperature sensors remain the most prevalent sensors, there are many sensors which can be usefully deployed in a data center. There are sensors for determining whether a cabinet door is open, the difference in pressure between two locations, the rate of airflow, and the presence of water. There are even sensors for tracking IT assets. This white paper will review some of the sensors which are useful in a data center.

There was a time, not long ago, when data center managers relied on the room thermostat to indicate the ambient temperature of a data center. They would set the temperature in the mid-60s°F to ensure adequate cooling. Now, most data center managers know that such an ambient temperature is unnecessarily cold and wasteful of energy.

A room thermostat only indicates the temperature at the thermostat's location, typically an interior wall. It is far more useful to know the temperature at the cool air inlets of IT devices. Being able to see plots of temperatures from multiple sensors can identify hot spots and areas of overcooling.

Sensor Design Considerations

Architecture

Sensors can be deployed as a separate overlay network or as part of an existing network. Deploying sensors as a separate overlay network requires a controller with its own network connections. The extra hardware and work to deploy network drops, which can cost $300 to $500 per drop, make an overlay approach to sensors expensive.

If sensors are deployed as plug-and-play options to rack PDUs there is no need for a separate controller which reduces cost. The data is communicated to energy management software via the Ethernet or Wi-Fi network used to control and monitor the rack PDUs. A Web-based GUI allows data center managers to report and plot sensor values in real time or over a period of time. With plug-and-play sensors no dedicated network needs to be established which eliminates the work and cost of cable installation.

Thresholds and alerts

One of the many benefits of sensors is an end user being able to set thresholds and alerts. For example, a temperature sensor can be set to send an alert if the temperature rises to a level where it might damage sensitive IT equipment. It can also be set to send an alert if the temperature falls below a threshold to ensure that energy isn't being wasted by overcooling the data center. It may even be necessary to set different thresholds for different locations. For example, the thresholds for the sensors on the cool air inlet side would be set lower than the sensors on the hot air exhaust side.

In general, higher levels of accuracy are preferred but the importance of accuracy varies depending on what is being metered and monitored. Energy usage, measured in kWh, should be accurate to +/- 1% to support billing or reporting.

For humidity, accuracy is less critical though data center managers should ensure that relative humidity (RH) guidelines are followed.

Types of sensors

There are analog and digital sensors. One isn't necessarily better than the other, it depends on the application and the nature of the deployment. Analog sensors tend to be smaller and therefore more easily deployed. Digital sensors can be more accurate but are often physically larger making some deployments awkward.

The form factor of a sensor can have big implications for how it is used. For example, temperature sensors at the cool air inlets of IT devices require small sensors that can be easily and unobtrusively mounted to the front of a rack.

Temperature and Humidity Sensors

Every Watt of power consumed by IT equipment is turned into a Watt of heat. As the power consumed at the rack has dramatically increased due to high-density racks so too has the heat generated by IT equipment.

Properly placing temperature sensors on a rack means temperatures can be plotted to ensure that IT devices don't overheat and that energy isn't being wasted by overcooling. Plotting individual sensors allows data center managers to identify hot spots requiring additional cooling or changes in the airflow or air pressure of the system to ensure adequate cooling is reaching all the locations where it is needed.

One of the most important organizations for data centers when it comes to heat and cooling is the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). They publish recommended IT equipment rack positions for temperature sensors. Specifically, sensors should be placed at the bottom, middle and top on the cool air inlet side.

Recommended IT Equipment Rack Positions for Temperature Sensors

Monitor Points

Rack with 2 Servers

Rack with 19 Servers
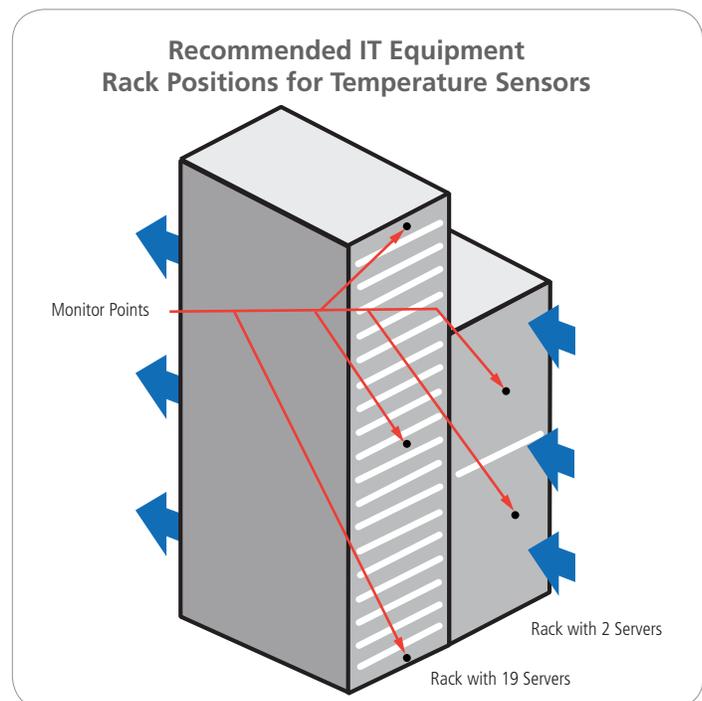
Source: "Thermal Guidelines for Data Processing Environments, 2ed" © 2009 ASHRAE

ASHRAE also publishes recommended ranges for temperature (65°F to 80°F, 18°C to 27°C) and relative humidity (20% to 80%). The upper end of the ASHRAE temperature range, 80°F, is approximately the point at which an IT device's fan turns on. Since both cooling infrastructure and internal fans consume power, the most efficient way to operate a data center is for the cool air at the device air inlet to be close to 80°F. Obviously, temperature sensors at the rack are an excellent way for a data center manager to improve efficiency.

One of the best ways to understand the relationship between temperature and humidity is to look at a psychrometric chart. The bottom of the chart is dry bulb temperature meaning air containing no moisture. The scale on the right of the chart is the amount of moisture in pounds contained in a pound of dry air. The curves running through the chart are the relative humidity (RH) from 0% to 100%. The temperature scale along the 100% RH curve is the wet bulb temperature.
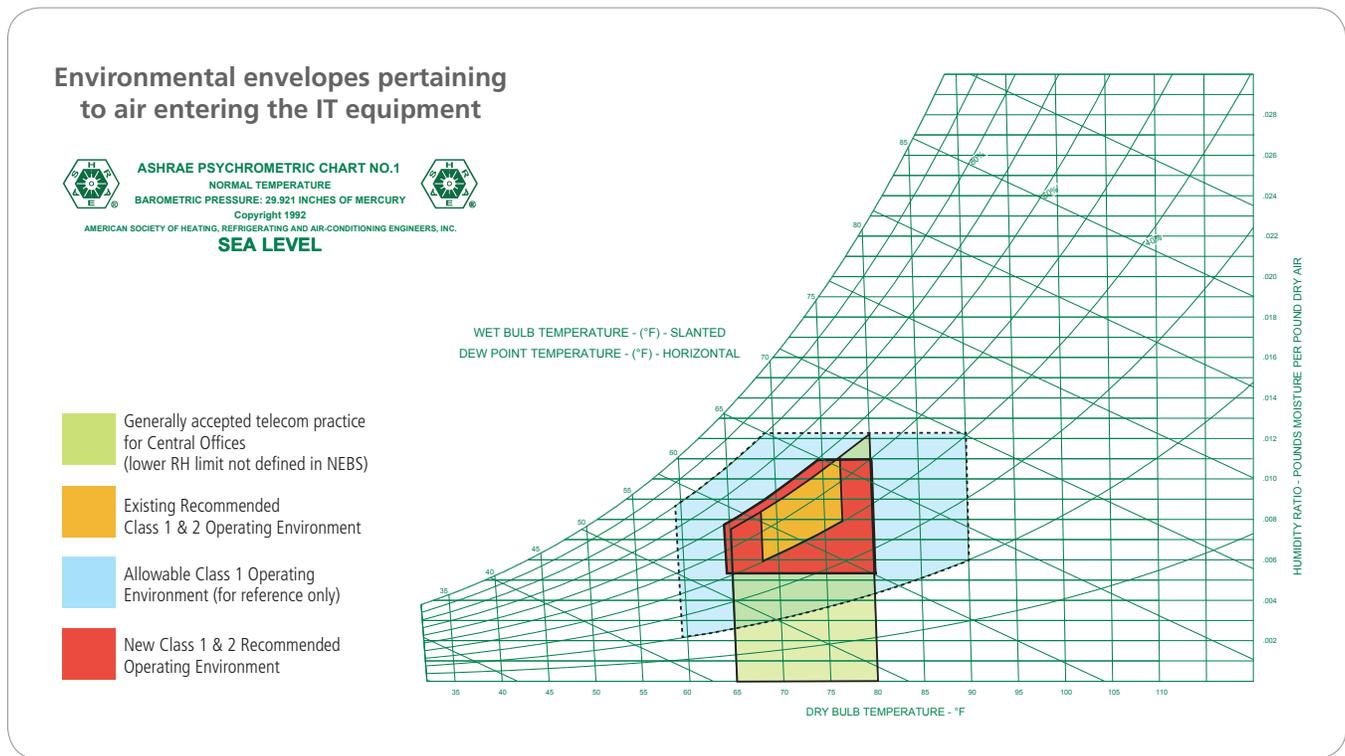
Source: "Thermal Guidelines for Data Processing Environments, 2ed" © 2009 ASHRAE

100% RH is the maximum amount of moisture the air can contain. Beyond this point, the dew point (DP), the excess moisture condenses into droplets. The height of the chart increases from left to right. This is because colder air can hold less moisture than warmer air.

If you fill a glass with ice water on a warm summer day condensation forms on the glass. This is because the air at the surface of the glass has cooled from say 75°F down to just above freezing at the surface of the glass. If the 75°F air had a RH of 50% that would be 0.019 pounds of moisture per pound of air. But, at 32°F air saturates (100% RH) at 0.004 pounds of moisture per pound of air. The excess moisture (0.019 – 0.004) becomes the condensation on the glass.

Data centers using airside economizers need to think about adding humidification because the cool outside air, say 40℉ and 50% RH which is approximately 0.003 pounds of moisture, comes into the data center and is then warmed by IT equipment to say 80℉. 0.003 pounds of moisture at 80℉ is less than 15% RH which is below the ASHRAE recommendation of at least 20% RH to minimize electrostatic discharge.

Airflow Sensor

The area under a computer room's raised floor is quite often used as a plenum for chilled air. However, this space can become cluttered with networking and power cables which can restrict the flow of cooling air. Often, when new power or network cables are run under the floor the old cables are left in place. Over time these obstructions build up and can seriously restrict air flow.

Perforated tiles allow the chilled air from the raised floor plenum to flow up to cool IT devices. Not only can this airflow be blocked by obstructions within the plenum but perforated tiles are available with various size holes. A cooling problem might be solved by changing to a tile with larger or smaller holes. It is important to monitor the chilled airflow but it can also be important to monitor the hot air return airflow.

Differential Air Pressure Sensor

In fluid dynamics, Bernoulli's principle states that for a fluid flow, an increase in the speed of the fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy. If you think about a shower curtain, before the shower is turned on the shower curtain hangs straight down. But when you turn on the shower the fluid inside the shower (air, steam and water) is moving faster than the fluid outside the shower (air) so the shower curtain is drawn into the shower because the pressure inside the shower has decreased.

For hot aisle / cold aisle deployments using variable speed fans to conserve energy, the difference in the flow of air between the two aisles can potentially cause less rigid partitions such as plastic curtains to be drawn into one of the aisles creating air leaks. A differential air pressure sensor set up to alert when thresholds are crossed can help identify if there are pressure differences that might lead to partition leaks and inefficiencies.

A chimney above a high-density / high-heat rack, and therefore high air pressure in the restricted volume of a chimney, might tend to leak hot air into a neighboring chimney above a low-density / low-heat rack and therefore low pressure. A differential air pressure sensor can indicate if such a condition exists.

Water Sensor

Water sensors can be used under racks to detect leaks. There are individual sensors and "rope" or "cable" sensors. A rope sensor can be laid under a row of racks and detect water anywhere along its length. A rope sensor can also be wrapped around pipes to detect leaks.

Contact Closure

Contact closure sensors can be set to be normally open or normally closed. They are often connected to third-party sensors and send an alert when the third-party sensor is triggered. For example, a contact closure sensor could be connected to a third-party smoke detection sensor and send an alert when smoke is detected. Or a contact closure sensor could trigger a webcam to take a picture when a cabinet door is opened.

Webcam

A webcam itself can be considered a sensor in that it monitors a data center by providing images. These can be still images as was mentioned in the example above in the contact closure section or video can be streamed such as in a surveillance application.

Management Software

All these data points provided by sensors need to be managed. Environmental sensors can play a key role in partial or complete data center infrastructure management (DCIM) solutions. Sensors can provide important inputs for establishing a baseline of initial conditions, identifying problem areas such as hot spots or water leaks and tracking and reporting improvements and savings. For example, trend reports showing increasing data center temperatures over time can be added to information on reduced cooling energy consumption and cost in a corporate social responsibility (CSR) report. Or data center managers can confirm that proper operating conditions have been maintained and they are in compliance with corporate, vendor or utility guidelines and requirements.
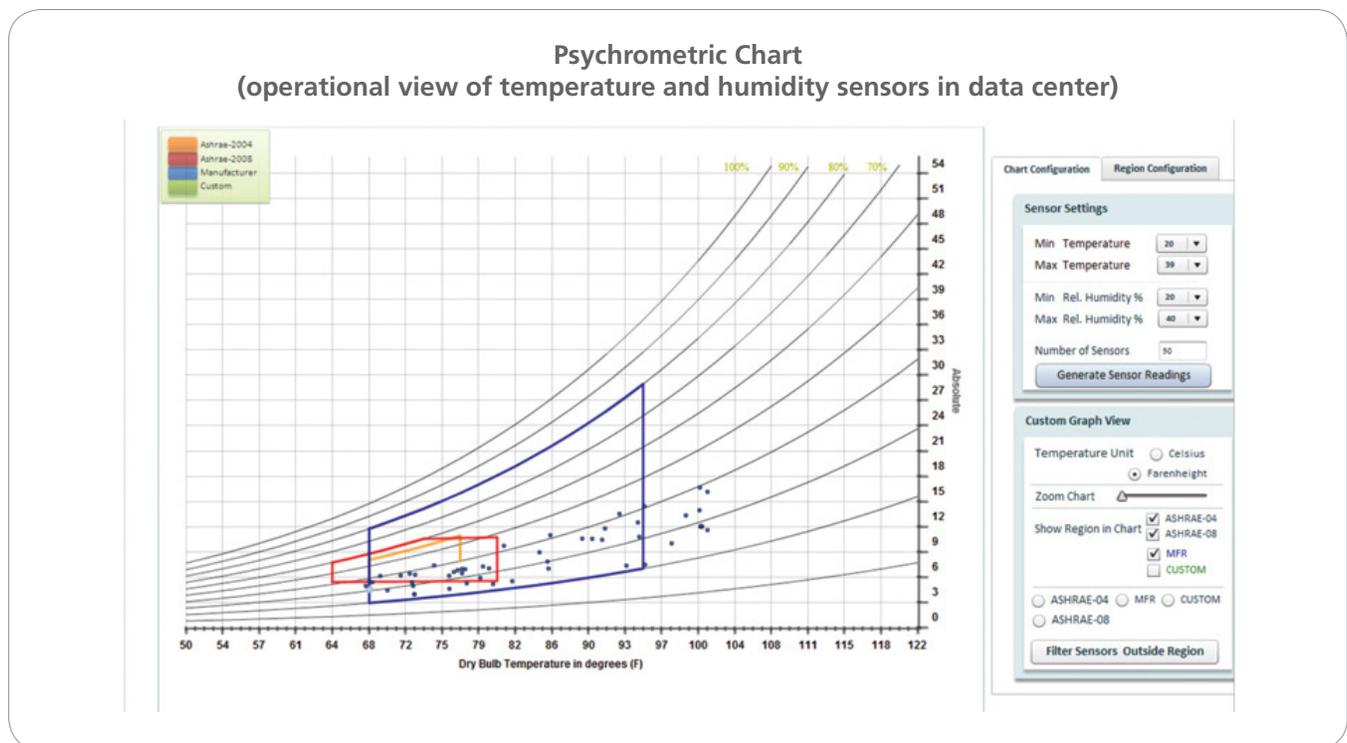
Source: Raritan Power IQ energy management software

Sensors are particularly useful as part of a capacity planning process. Do you have adequate cooling where it is needed? Energy management software that can plot temperature sensor data on a psychrometric chart as described earlier gives data center managers a view as to what is happening where. Are some racks in hot spots? Do some areas of the data center require humidification? Careful planning is required when changing cooling infrastructure. There can be unintuitive consequences. For example, putting in additional air conditioning units might actually make existing hot spots worse or create new ones if the units disrupt airflow patterns.

The Benefits Of New Technology, Solutions And Tools

A data center, whether a room or an entire building, is all about what is happening at the rack. The right environment monitoring and metering at the rack can lead to some nifty data center improvements – right sizing the data center and just-in-time expansions to save on capital expenses; improved energy efficiency, IT productivity and utility; and better integration with cloud computing.

The right way to look at a data center is not as a number of different IT devices and supporting infrastructure such as cooling and power distribution. Instead, look at a data center as a system. Each of the components has an impact on the other components. For example, replacing 1U "pizza box" servers with blade servers can significantly increase the amount of power consumed, and the amount of heat that must be removed from a rack. Bringing in DCIM software data points from several different types of sensors lets data center managers see their total operation as a whole yet with the ability to drill deeply into specific details.

An environment management and monitoring program using one or more of the sensors described in this white paper is a good step towards really understanding a data center. Use technology, solutions and tools to make intelligent use of all your IT resources including IT assets, power, cooling, networks and, of course, people.

About Raritan

Raritan is a proven innovator of power management, infrastructure management, KVM and serial solutions for data centers of all sizes. In more than 50,000 locations worldwide, Raritan's award-winning hardware and software solutions – including intelligent rack PDUs; energy management software; DCIM software solutions to effectively manage data center capacity, assets and change; KVM-over-IP and Serial-over-IP access products – provide IT and facility directors, managers and administrators with the control they need to increase power management efficiency, improve data center productivity and enhance branch office operations. Based in Somerset, NJ, Raritan has offices worldwide serving customers in 76 countries. Visit us at Raritan.com or follow us on the Raritan blog. Raritan is an active member of the Green Grid, Climate Savers Computing Initiative and the Leadership in Energy and Environmental Design associations. The company was recognized by the EPA for its contribution to the agency's data center initiative.