White Paper

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Best Practices for Wire-free Environmental Monitoring in the Data Center

Introduction

Monitoring for environmental threats in the data center is not a new concept. Since the beginning of modern data centers, the temperature of servers and network equipment has been a constant concern as one of the most threatening environmental conditions. The idea that servers need to be "protected" from environmental threats and operated only under the right conditions coincided with the explosion of client-server computing. Together, both were the driving factors behind the creation of the modern data center in the late 1980's and early 1990's.

Since then, the physical construction, physical layout, and implementation of a data center has steadily improved, optimized to accommodate the ever-changing requirements driven by advances in server and storage technology. The methods and mechanisms to monitor for physical threats in the data center have also evolved. In this paper, we will explore wire-free environmental monitoring best practices, one of the newest developments in data center physical threat monitoring.

Environmental Threats in the Data Center

Before diving into the best practices for monitoring environmental threats with wire-free sensors, let's first review the top physical threats to the data center and impact of these threats.

Temperature

The first and most important physical threat to the data center is temperature. There are many physical locations in the data center where temperature is critical:

- Air temperature in the plenum spaces such as raised floors, especially far away from the CRACs
- Air temperature above the plenum and in front of the racks on cold aisles (i.e., the intake air for the servers in the racks)
- Air temperature inside the IT racks themselves, especially if the racks are fully enclosed (doors front and rear as well as sides)

Humidity

Humidity is like air temperature in that it can vary throughout the data center, although it typically does not vary as much. It is not uncommon for data center humidity readings to vary with the outdoor humidity conditions. Most modern CRACs (computer room air conditioning unit) have the ability to control (increase or decrease) the humidity in the data center.

The danger of low humidity conditions in the data center is threat of electrostatic discharge (ESD), which can damage electrical components. The result of high humidity in the data center is the possibility of condensation. ASHRAE currently recommends a range of 40%-55% for data center humidity.

Water or Fluid Leaks

Water or fluid leaks in the data center are definitely a concern. The severity of this threat to a data center varies according to construction details, equipment use and water/fluid systems placement. Many systems use fluid or water for cooling from CRACs to water cooled systems to fire suppression systems. The impact to the data center from fluid or water leaks is damage to electronic systems and cabling.

Door Position

The position of rack doors and room doors is directly related to the physical threats of are air flow/ cooling and access control. Proper and efficient air flow and cooling are constructed around a known or fixed configuration, which incorporates the knowledge that doors to racks and rooms are supposed to be open or closed. Normal open and closing of a door in a short period of time typically does not impact air flow and cooling. However, doors that are propped open for extended periods of time can cause issues.

Air Handler or CRAC Failure

Understanding, even at the most basic level, the state or health of a CRAC in the data center is essential. Not all CRACs and air handlers have network monitoring and management capabilities, particularly older units and models. However, most CRACs and air handlers (as well as generators) typically do have dry contact monitoring capabilities. Dry Contact is basically a relay that makes or breaks a circuit to indicate a status change or fault with a device. So a CRAC, for example, may have one or more dry contact connection points that may indicate things such as fan status (normal or fault) and compressor status (normal or fault). Proactively monitoring the status of CRAC units, even at a basic dry contact level, can reduce the impact of a failure and increase the amount of time available to respond to the issue.

Physical Threat Summary

The following is a summary table of the most common physical threats to a data center, their impact and the right sensor to monitor proactively for these threats.

Threat	Applicability	Impact	Sensor
Temperature	• Data Center • Inside Racks • Plenum Spaces	High temperatures reduces equipment life span	Temperature Sensor
Humidity	• Data Center • Inside Racks • Plenum Spaces	Electrostatic buildup at low RH and condensation at high RH	Humidity Sensor
Liquid Leaks	• Beneath Raised Floor • Liquid Sources • Liquid Cooled Racks	Liquid (water) damage to equipment, cabling, floors, etc.	Liquid Sensor
Door Position	• Data Center • Racks	Disruption to normal air flow as well as security issues	Door Position Sensor
Cooling Failure Air Movement Failures	• CRACS • Air Handlers	Results in high air temperatures	Intelligent CRACS and/or Dry Contact Sensor

Best Practice Sensor Placement

An acquaintance of mine who runs the IBM Green Data Center in Austin Texas, uses the following phrase when he communicates how he manages the data center: “Intelligent data allow for intelligent decisions.” In other words, the more information you have about the conditions in your data center, the better equipped you are to make decisions regarding the optimization, expansion, and utilization of your data center. Environmental monitoring and physical threat sensors provide the infrastructure to collect intelligent data throughout the data center.

Now let’s look at the best practice methods for sensor placement to proactively monitor for physical threats in the

data center.

Temperature Sensors

There is no single answer to what is the ideal placement for temperature sensors in a data center. Multiple factors influence the quantity and location of the temperature sensors needed to properly. These include data center design, load, capacity, percent utilization, and efficiency goals. The "classic" way of running a data center was to cool the data center regardless of cost and efficiency. With the new "green" way of thinking and the fact that operational costs of now outweigh the capital costs of a data center, the concept of overcooling has lost favor.

For cold aisles and hot aisles the quantity of sensors can vary, depending on your monitoring goals and budget. For closed racks with doors, it is recommended to place the sensor on the inside of the rack door. For open racks without doors, it is a matter of convenient and secure mounting location more than anything else. A good location for open racks is the left or right side of the rack but not interfering with the equipment "U" space. The following are three best practice recommendations around the placement of temperature sensors:

- Minimal temperature sensor coverage
    - One temperature sensor in the front of every rack at mid-point of the height of the rack
    - One temperature sensor in the rear of every five racks at mid-point of the height of the rack
- Typical temperature sensor coverage
    - Two temperature sensors in the front of every rack, with one mounted about sixteen inches from the bottom of the rack and one about sixteen inches from the top of the rack
    - One temperature sensor in the rear of every other rack at mid-point of the height of the rack
- Maximum temperature sensor coverage
    - Three temperature sensors in the front of every rack, with one mounted about twelve inches from the bottom, one mounted in the middle and one mount about twelve inches from the top of the rack
    - One temperature sensor in the rear of every rack at mid-point of the height of the rack

The following illustration shows proper placement of temperature sensors (assuming maximum coverage) in the front of a closed rack.

Regardless of the mounting location and quantity

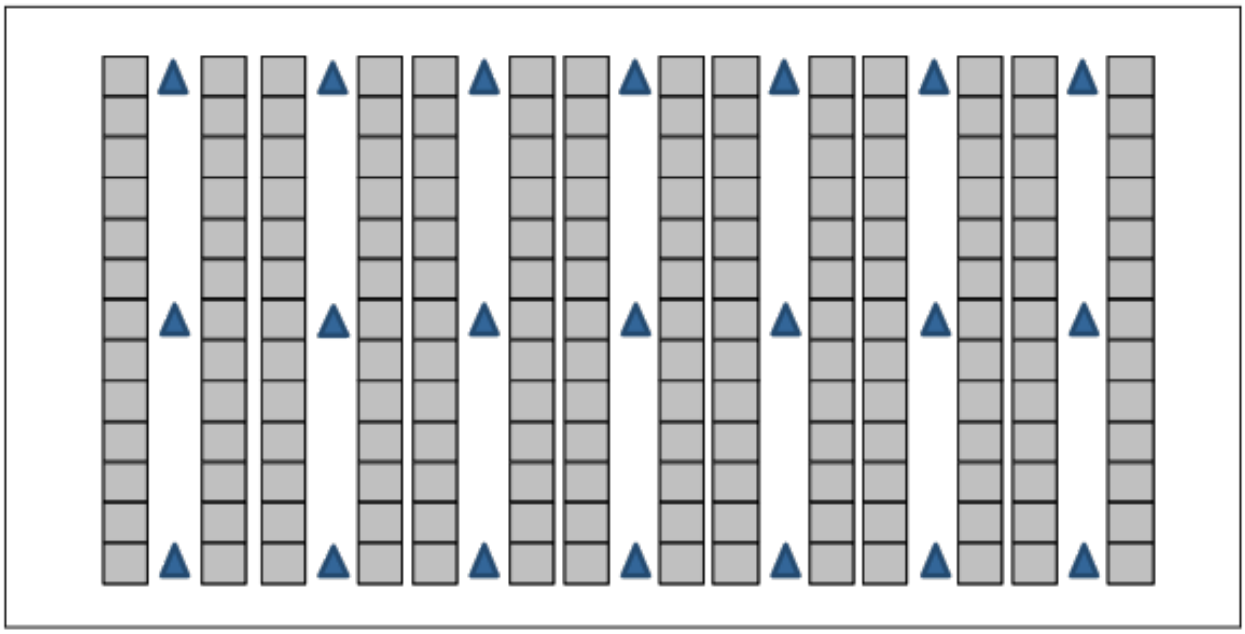
of temperature sensors used, always mount sensors consistently from rack to rack and row to row.

To better understand the environment in the plenum, additional temperature sensors may be placed in plenum spaces such as below raised floors.

Humidity Sensors

Humidity does not vary as quickly in a data center as temperature. Therefore, fewer humidity sensors are needed. Humidity sensors are typically placed on cold aisles and spaced fairly far apart. The following are three best practice recommendations around the placement of humidity sensors:

- Minimal humidity sensor coverage
    - One humidity sensor per row placed in the front of a rack in the middle of the row
- Typical humidity sensor coverage
    - One humidity sensor for every five racks placed in the front of a rack
- Maximum humidity sensor coverage
    - One humidity sensor for every three racks placed in the front of a rack



As with temperature sensors, humidity sensors should always be mounted consistently throughout the data center.

Liquid Sensors

Liquid or leak sensors should be placed near the potential sources of the liquid. The most common fluid source in the data center is the CRACs. However, more sources may be present in your data center. So it is best to involve the facilities manager who can indentify pipes that may be hidden behind walls as well. Additional sensors may be needed if your data center is in the basement level of building (or even partially below ground level) because of potential water seepage from outside walls.

Door Position Sensors

At a minimum, door sensors should be placed on all doors that provide access to the data center, even if an access control system is installed. In addition, door sensors may be installed on the front and rear of IT racks.

Dry Contact Sensors

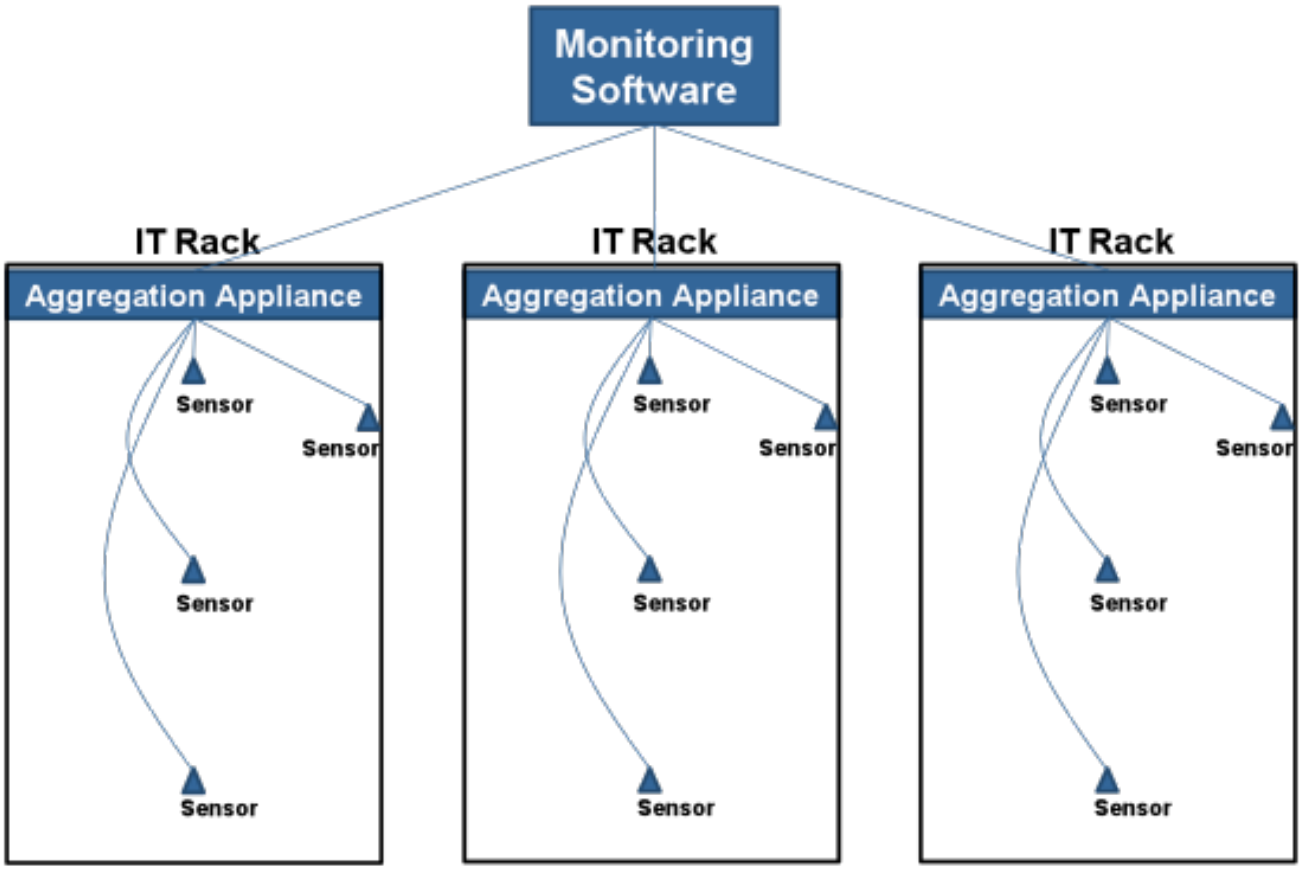
Any CRAC or air handler not monitored via SNMP should have a dry contact sensor attached. Note that outdoor generators as well as UPS systems usually have dry contact connection points as well.

Shortcomings of Wired Environmental Monitoring Solutions

The traditional wired environmental monitoring systems on the market today typically consist of the following components:

- Aggregation appliances that install in the IT rack, host the environmental sensors and are accessible via TCP/IP network
- Wired sensors that physically connect to aggregation appliances
- Monitoring software that communicates to aggregation appliances to collect sensor information

These traditional wired environmental monitoring solutions are usually deployed in one of two ways. Some solutions require installing an aggregation appliance in each IT rack. Once the aggregation appliance is installed, then the wired sensors must be connected to the appliance and then placed in the appropriate position in the rack. Other solutions dictate installing one aggregation appliance for a row or group of IT racks. In this case, the environmental sensors from each rack are cabled back to the one appliance, which means there are cable connections between racks. Regardless of the deployment approach, wired sensors are required and disciplined cable management practices must be followed during the installation.



Traditional wired environmental monitoring solutions have a number of drawbacks in light of the newer wire-free solutions.

1. The cost of a wired solution is substantial. Using the assumption that a typical aggregation appliance costs about $800.00 and each environmental sensor costs about $99.00, the following estimates can be made.

    a. Assuming a 250 rack data center where one aggregation appliance and three sensors are installed in each rack, the total cost would be $274,250.00 or $1,097.00 per rack.

    b. Assuming a 250 rack data center where one aggregation appliance is installed for every 5 racks and three sensors are installed each rack, the total cost would be $114,250.00 or $457.00 per rack.

2. The entire concept of aggregation appliances that physically connect to sensors is scale limiting and costly. Aggregation appliances have a limited number of ports or connections for external sensors. As more sensors are added to the rack, more aggregation appliances are required. It is important to understand that future expansion is limited to the number of available ports on the aggregation appliances.

3. Aggregation appliances consume valuable rack space. Some aggregation appliances must be installed in a "U" space, which is extremely valuable real estate in a high density data center. Other aggregation appliances are designed to be installed in zero-"U" spaces, but these are often fully used by intelligent PDUs in the rear of the rack. Finally, aggregation appliances require power and Ethernet connections.

4. Lastly, the cost to deploy a wired monitoring solution is quite costly. Assuming an hourly rate of $100.00 per hour, 30 minutes to install an aggregation appliance and 15 minutes to install a wired sensor, the following estimates can be made:

    a. Assuming a 250 rack data center where one aggregation appliance and three sensors are installed in each rack, the total time to install the solution= 312 person hours or 39 person days. The total cost would be $31,200.00.

    b. Assuming a 250 rack data center where one aggregation appliance is installed for every 5 racks and three sensors are installed each rack, the total time to install the solution would be 212 person hours or 26 person days. The total cost would be $21,200.00.

Advantages of Wire-free Environmental Monitoring Solutions

The new wire-free environmental monitoring solutions on the market today are typically comprised of the following components:

- Battery-powered small wire-free sensors
- Radio frequency (RF) receivers that collect data from the wire-free sensors and are accessible on the TCP/IP network
- Monitoring software that communicates to receivers to collect information from wire-free sensors

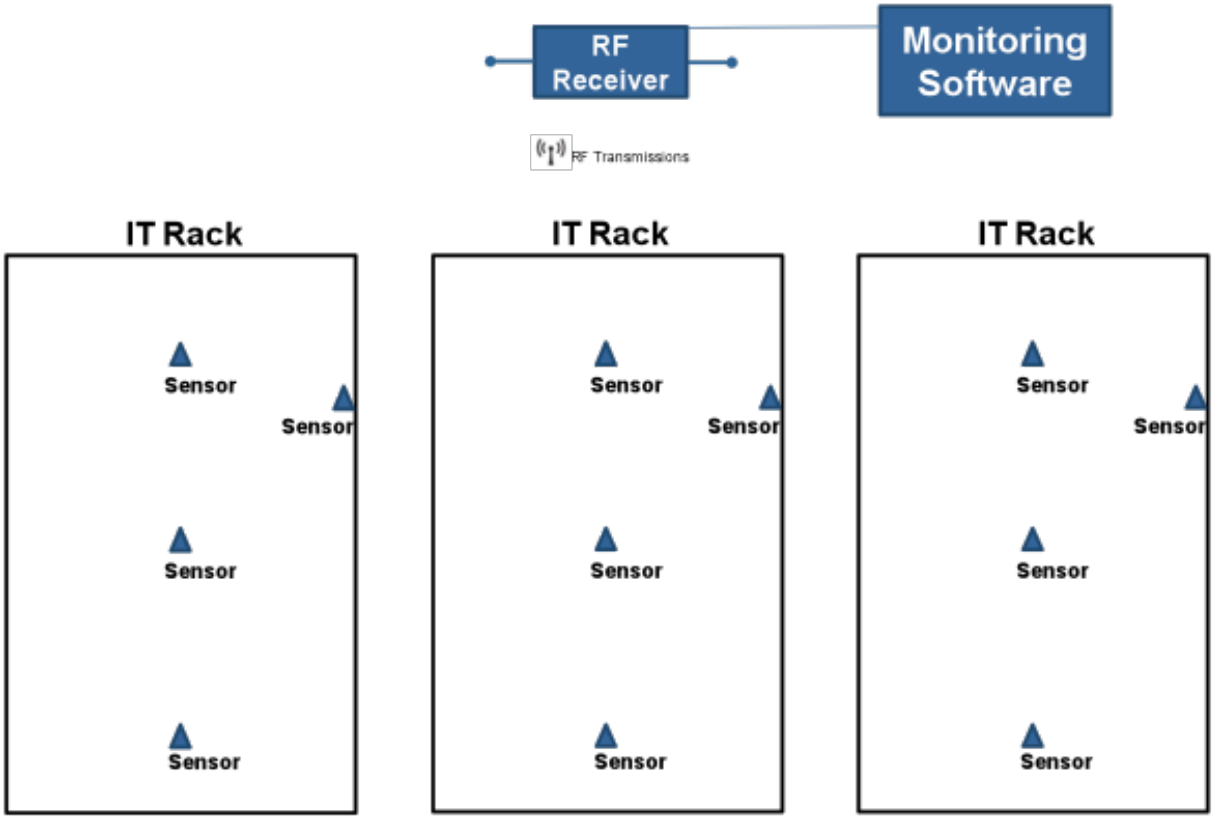
Not all wire-free sensor solutions are the same. It is important that a wire-free sensor solution has the following characteristics:

- Small and inexpensive wire-free sensors, NOT small boxes with wired external sensors
- Minimum 3 years battery life on all sensors, with replaceable batteries
- Long range, wire-free communications between sensors and RF receivers that must work inside racks with doors and sides
- Simple setup and configuration that does not require "special" radio communications skills

Wire-free sensor solutions are typically deployed installing

one or more RF receivers in the data center. These RF receivers require power and an Ethernet connection. RF receivers should easily cover 2000 square feet at a minimum. The wire-free sensors themselves should be very small and easy to install inside and outside the IT rack.

Wire-free sensors should be installed by simply "sticking" them to the rack using adhesive. This makes deployment time extremely fast. The most important item to note is that there are no wires to purchase, install and manage.



Wire-free environmental monitoring solutions have a number of advantages over the traditional wired approach.

1. They typically cost much less than wired solutions. When using wire-free solutions, sensors usually cost between $40.00 and $90.00. The RF receivers usually cost between $1,000.00 and $1,300.00. The best wire-free monitoring solution RF receivers should easily handle 2,000-4,000 sensors and cover thousands of square feet of data center. Using the assumption that a RF receiver costs about $1,000.00 and each environmental sensor costs about $79.00, the following estimates can be made.

   a. Assuming a 250 rack data center where one RF receiver covers about 20 racks (conservative RF coverage) and three sensors are installed in each rack, the total cost would be $71,750.00 or $287.00 per rack.

   b. Assuming a 250 rack data center where one RF receiver covers about 40 racks (typical RF coverage) and three sensors are installed in each rack, the total cost would be $65,500.00 or $262.00 per rack.

2. There are no wires to install and manage with wire-free solutions.

3. Wire-free monitoring solutions do not consume any valuable rack space because the RF readers are typically

mounted to the data center ceiling.

4. Properly designed wire-free solutions have a very high sensor- to-RF receiver ratio that allows for massive scalability. New sensors can be added without worrying about wiring connections and cabling restrictions.

5. In most wire-free sensor solutions, more than one RF receiver can receive the RF broadcast from each tag. Having multiple RF receivers with the same coverage zone eliminates the single point of failure of aggregation appliances.

6. Lastly, the cost to deploy a wire-free environmental monitoring solution is substantially less than a traditional wired solution. Assuming an hourly rate of $100.00 per hour, 30 minutes to install a RF receiver and 5 minutes to install a wire-free sensor, the following estimates can be made.

    a. Assuming a 250 rack data center where one RF receiver covers about 20 racks (conservative RF coverage) and three sensors are installed in each rack the total time to install the solution=68 person hours or 8.5 person days. The total cost would be $6,800.00.

    b. Assuming a 250 rack data center where one RF receiver covers about 40 racks (typical RF coverage) and three sensors are installed in each rack, the total time to install the solution=65 person hours or 8.2 person days. The total cost would be $6,500.00.

Environmental Monitoring Software – the "Must Have" Capabilities

The monitoring software provided as part of the environmental monitoring solution is just as important as the sensors themselves. The monitoring software turns thousands of data points into valuable and usable information. The following are characteristics for environmental monitoring software:

- The software must be very scalable and must be able to handle tens of thousands of sensors
- The sensor location is the primary attributes with sensor readings the secondary attribute. The data are useless without knowing the exact location of each sensor
- Centralized policy based thresholds provide simplified management and enable "mass management"
- Multiple notification methods for threshold breaches such as SNMP, email, HTTP Post, are a must
- The software must be an open system that allows easy integration with enterprise class monitoring solutions in the data center such as Tivoli, HP, CA and building management systems.

Conclusion

Wired environmental monitoring solutions are the old and expensive way to monitor your data center. Wire-free environmental monitoring offers the following key advantages:

- Has a lower cost
- Is cheaper and easier to deploy
- Saves critical rack space
- Provides massive scalability and future expansion

If you are considering an environmental monitoring solution for your data center, don't make the mistake of doing it the "classic way." Green initiatives depend on instant and continuous visibility into data center hot and cold spots. Having the right information at the right time is more important than ever. A wire-free approach ensures you have both.

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