



February 2016

CFD Analysis or Real-Time Monitoring?

Introduction

Increasing energy costs and power densities in Information Technology (IT) spaces are driving up operational expenses (OpEx) and causing many facilities to run out of capacity much sooner than anticipated. To control OpEx and avoid the capital expenditure (CapEx) required to build new facilities, IT space operators are looking for ways to improve energy efficiency through optimal thermal management. Two tools for improving thermal performance are Computational Fluid Dynamics (CFD) analysis and real-time monitoring. CFD analysis is a snapshot of the thermal performance of an IT space. This snapshot can reveal the root causes of issues that affect the efficiency and effectiveness of a thermal management system. CFD analysis is also the best tool for predicting future thermal performance, based on projected changes to an IT space. Real-time monitoring provides continuous feedback of the current IT environment, but provides no analysis of the causes behind the conditions monitored. Before having a CFD analysis performed or deploying a sensor network, it is important for an IT manager to fully understand the differences between these two tools.

Computational Fluid Dynamics (CFD)

CFD is a technique that produces quantitative predictions of fluid flow within a defined system based on the conservation laws governing fluid motion (conservation of mass, momentum, and energy). These predictions are made for a system where physical geometry, physical properties of a fluid, and the boundary and initial conditions of a flow field are well defined. The prediction is focused on a set of fluid variables, for example, temperature, pressure, and velocity that can describe the fluid flow and heat transfer within the system. CFD complements experimental and theoretical fluid dynamics and is an effective research and design tool. Some of the advantages of CFD include:

- Generates air temperatures, pressures, and velocities for any location in the system
- Useful in design optimization as modifications and variations can be easily modeled and tested
- Features in the model can be easily switched on and off to allow for faster solution time
- Inexpensive and quick when compared to building and testing design mockups

Running CFD models can be a cumbersome and time-consuming process, but the continuous advancements in processing speed and automated meshing techniques have reduced solution times significantly. As a result, CFD use is growing in a variety of applications, including the design of aircrafts, cars, power stations, combustion engines, clean rooms, hospital rooms, IT equipment, and IT spaces. Over the last two decades, as IT power densities and operational costs have risen, many companies have developed CFD software catered to the modeling of IT spaces, which has proven to be effective in designing more efficient IT equipment and spaces.

A CFD model of an IT space includes geometric data, such as the floor plan, raised or slab floor specifications, obstructions, floor tiles and grilles, return grates, ducting, IT equipment racks and cabinets, IT equipment units, and cooling equipment. The accuracy of the model is highly dependent on the accuracy and completeness of this information as well as the level of detail modeled for each component in the IT space.

Panduit Professional Services Assessments

The Panduit Professional Services team provides a variety of physical infrastructure services for data communications, enterprise, and industrial automation. The team relies heavily on CFD modeling in assessing IT facilities and in validating proposed designs. Panduit has found that using CFD to predict the future state of the IT space before the deployment of proposed designs helps establish a level of trust with customers. It allows various options to be evaluated and the best configuration to be selected with confidence before incurring the cost of deployment. When it is impossible to physically test or collect data, CFD analysis can be used to:

- Determine the optimal configuration of cooling equipment and layout of an IT space
- Identify areas of inefficiency, such as airflow leakage and obstructions
- Identify airflow issues that cannot be seen, such as vortices in the distribution plenum and recirculation of hot air in and around cabinets
- Analyze what-if scenarios, such as an increase in the heat load with the deployment of additional IT equipment, the deployment of additional cabinets, the rearrangement of existing cabinets, or cooling unit failure
- Test the effectiveness of proposed thermal management solutions, such as aisle containment or Vertical Exhaust Systems (VESs)
- Demonstrate to customers the savings associated with different options and predict the Return on Investment (ROI)

Figure 1 illustrates how CFD modeling can predict the effect of a change to the thermal environment of an operating data center, for example, when adding cold aisle containment. The temperature plot on the left in Figure 1 shows that, without containment, the hot and cold air in the data center are mixing and that, even with supply air being provided at a wastefully cold temperature, the temperatures in some of the equipment cabinets are still high. The high temperatures put the IT equipment housed in the cabinets at risk of overheating. The graphic on the right in Figure 1 shows that, with cold aisle containment, hot and cold air would be completely separated and the supply air temperature could be raised, reducing OpEx. However, all the cabinets would be properly cooled.

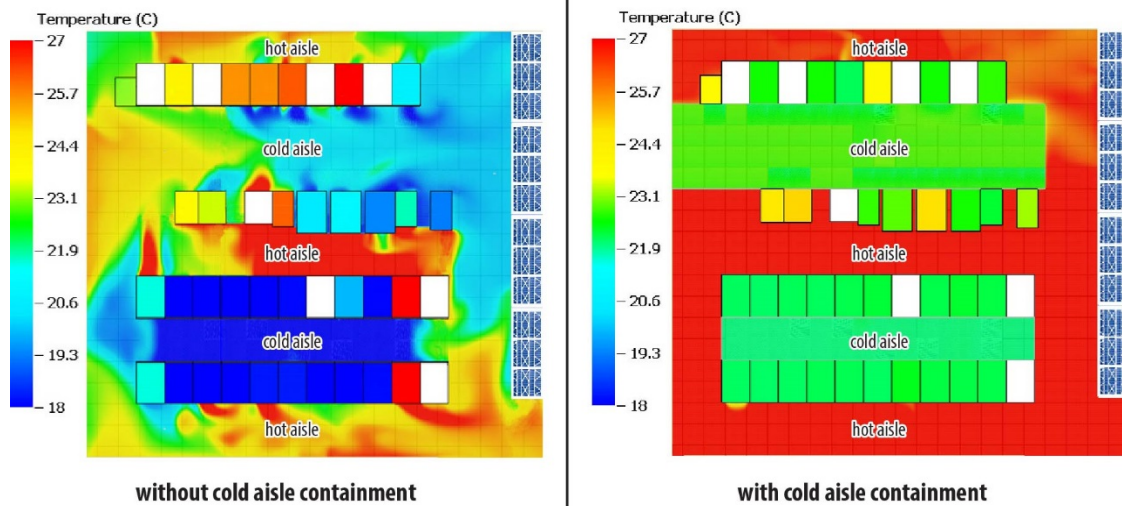


Figure 1. Horizontal Plots of Temperatures in a Data Center without and with Cold Aisle Containment.

Real-Time Monitoring

Real-time monitoring solutions for IT spaces use wired or wireless sensors to measure environmental conditions including temperature, pressure, humidity, and power at specific locations. The measurements collected are transferred through wired or wireless gateways to central monitoring software, typically on a stand-alone server. The central monitoring software uses the measurements to generate real-time color-coded thermal, pressure, and humidity maps, which allows the user to quickly identify hotspots, low and high pressure zones, and regions with abnormal humidity levels. Though the measured sensor data is from specific locations, the software uses linear or non-linear interpolation between the measurements to provide the color-coded maps. Many of these software solutions also give users metrics, which can show the health and efficiency of the IT space's environmental management system, and trigger alarms when anomalies or failures occur. Some of the advantages of environmental monitoring include:

- Helps with monitoring dynamic changes in real-time
- Allows monitoring near the IT equipment where it is most critical
- Identifies temperature, pressure, humidity, and power anomalies
- Provides user with alarms for environmental anomalies
- Enables cooling optimization in the IT space
- Supports automated control of the cooling equipment to save energy and increase reliability

Panduit's Real-Time Monitoring Solutions

Panduit SmartZone™ Solutions provide wired and wireless sensor options suitable for both Brownfield and Greenfield IT spaces. Wired options offer both passive and intelligent hardware to capture and process real-time data for all critical parameters, including power usage, environmental status, asset tracking, network connectivity, and security (access control). Wireless options offer hardware that is focused on the environmental status of the IT space (temperature, pressure, and humidity). These options use a patented wireless mesh technology that is self-configurable, self-healing, secure, reliable, and scalable to thousands of devices. Data is transferred from the distributed wireless sensors, through wireless gateways, to the SmartZone™ Data Center Infrastructure Management (DCIM) Cooling Software. The software provides thermal, pressure, and humidity maps through a Livelmaging™ feature for daily IT space management. Figure 2 shows a typical Livelmaging™ screen capture of a data center airflow management thermal map in real time, which can reveal thermal anomalies and cooling inefficiencies. The SmartZone™ Cooling Software also has an Active Control™ feature that provides data center managers the ability to continuously align cooling capacity with changes in IT load for better energy efficiency. The Active Control™ feature can save customers up to 50% on their cooling energy costs.

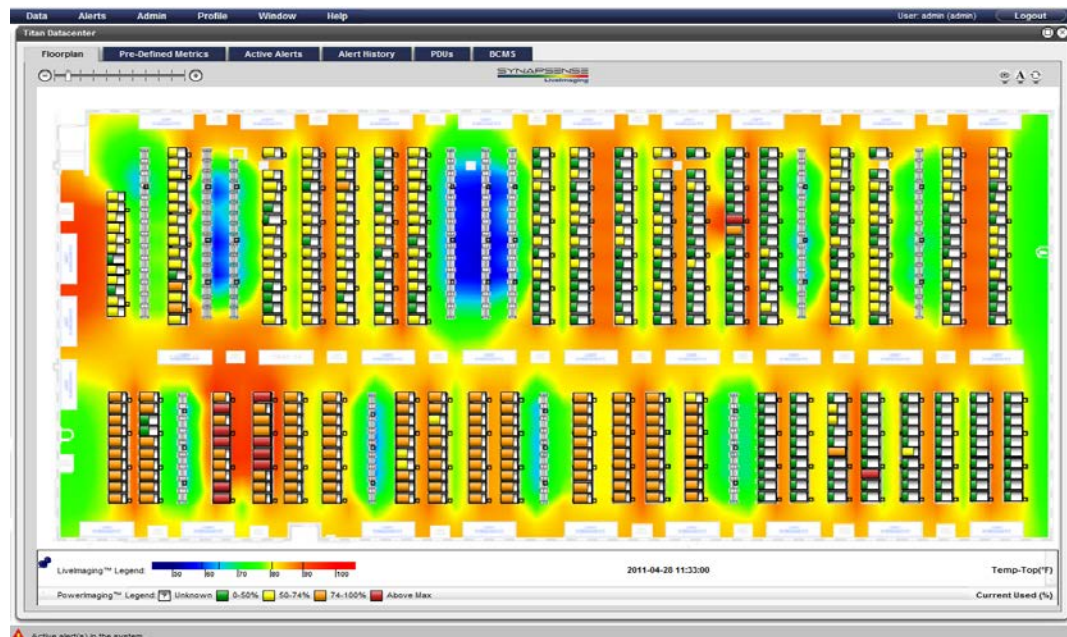


Figure 2. Livelmaging™ Sample Features Real-Time Thermal Map.

CFD or Real-Time Monitoring?

Neither CFD nor real-time environmental monitoring can replace the other. Both approaches provide users with capabilities to better manage their IT space and improve energy efficiency. However, each approach differs in its application, reliability, and accuracy, and users must understand these differences before choosing either technology. Table 1 summarizes the differences between CFD and real-time monitoring.

Table 1. Comparing CFD and Real-Time Monitoring.

	CFD	Real-Time Monitoring
Applications	Predictive modeling, IT space design, identifying areas of inefficiency, analyzing complicated flow issues.	Identifying anomalies, operational efficiency, cooling equipment tuning, automated control, alarms.
Ease of Use	Extensive training required. Usually a services/consulting firm performs the CFD analysis. Does not require strong data communications facility experience.	Experienced data communications field service personnel are required to install and fine tune the monitoring system. Once the monitoring system is in place, simple training is sufficient.
Reliability	May require calibration with real data.	Based on real data.
Accuracy	Depends on user inputs and assumptions. If user inputs are accurate, the modeling of every location in the IT space can be considered accurate.	Accurate at sensor locations. The more sensors that are deployed, the more accurate the interpolation between sensors.
Response	Provides a one-time snap shot of the IT space based on inputs. Models can take hours to solve depending on the level of detail.	Dynamically responds as the IT space environment changes. The response rate depends on the frequency of measurements and reporting.

Data Center Infrastructure Management (DCIM)

Despite the differences between CFD and real-time monitoring, both can complement each other in various IT space applications. However, once an IT space is operational, improvised decisions are often made that affect space, power, cooling, and network management. Over time, these decisions can cause an inefficient IT space with stranded (lost) capacity, causing IT space operators to face the high CapEx of building a new facility sooner than expected. DCIM solutions can help solve these issues and are promoted in the industry as the ultimate data center management tool. They provide customers with an overall view of their data center's current health, capacity, and energy efficiency by using environmental monitoring to collect real-time information on environmental conditions, cabinet IT equipment, cabinet power, and networking connections. DCIM solutions also give the user actionable intelligence through graphs, charts, and metrics.

Conclusion

Integrating CFD and real-time environmental monitoring can provide data center managers with a complete set of performance data for an IT space at any point in time—past, present, or future—which is invaluable for maintaining peak efficiency. Using CFD as a predictive tool can offer cooling capacity management features to the DCIM software suite by determining the impact a future IT equipment deployment will have on the data center environment. If only a few additional pieces of IT equipment are to be installed, monitoring alone is sometimes enough to identify acceptable deployment locations with adequate cooling. However, for larger equipment rollouts, CFD becomes necessary to test designs and predict the effects of Moves, Adds, and Changes (MACs), and to maintain energy-efficient environmental set points.