

Part 6: Timeless Best Practices

Changing Landscape Of Data Centers

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Few industries have changed as significantly or rapidly as that of information technology and, consequently, the data center. As the equipment housed within the data center has grown increasingly hungry for power and cooling, so has our global need for the services that it provides.

The evolution of IT equipment has included some major step changes. From vacuum tubes to bipolar transistors to CMOS integrated circuits, each successive generation of equipment has continuously improved with large step functions.

The cutting-edge data center has also experienced a combination of continuous evolution and stepped change. Yet, the longer lifetime of the data center has resulted in complicated mixed-generation environments that can't always keep up with the cutting-edge.

Consequently, there can exist a large gap between the data center infrastructure and its IT equipment as each change at a different pace. Despite this, some of the best ways to address these gaps is to follow some of the industry's best practices that have been around for years and are still completely relevant.

This article will examine a few of these recommendations as published in ASHRAE's *High Density Data Centers: Case Studies and Best Practices*.¹

Hot Aisles and Cold Aisles

In the earliest days of IT equipment and continuing for some time, the form factors of IT equipment could vary wildly. There was a lack of meaningful interface standards and, therefore, the role of the data center was a

particularly tricky one, needing to accommodate a large variety of equipment.

If all the equipment was air-cooled, then the task of supplying equipment with cold air was straightforward; get the air near the equipment. With various pieces of equipment moving air from front to back, bottom to top, or even back to front, there was little possibility of optimizing airflow. Supply and return air would mix throughout the space and thus the overall goal was to simply cool the room the IT equipment was located in.

When equipment began to be more standardized, particularly moving air from the front to the rear, it offered the opportunity to create hot and cold aisles. In effect, this enabled the concentrating the return air and preventing mixing with the supply air. Though less mixing of the hot and cold airstreams, less fan energy could be expended to achieve the same levels of performance.

Today, aligning equipment into hot aisles and cold aisles, or otherwise separating the supply and return air, is still one of the best practices that can be applied in a data center. And yet, even today, there are plenty of data centers that do not adhere to this principle and are needlessly energy inefficient.

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For air-cooled IT equipment, although the components and design of data centers may change, it is highly unlikely that hot aisles and cold aisles will be replaced any time soon. However, we're likely to see even further advances in the separation of the supply and return air-streams that offer more flexibility, easier installation, and more complete separation.

Accommodating Growth

Change is unavoidable in the data center. To stay relevant, the data center must be able to accommodate the growth (or sometimes contraction) of capacity and load. This means that the design of the data center must include flexibility regarding where or how it delivers power and cooling throughout the space.

For maximum flexibility, the design should be optimized for variable locations of IT equipment, not fixed or predetermined locations. This approach provides the most flexibility for IT equipment changes over time, but may result in compromises in other areas like costs or energy efficiency. This approach also allows for changes in the IT equipment form-factor (footprint dimensions, heights, weights, equipment cooling class, etc.).

Phasing (modular or scaled) is another method where growth can be accommodated. If the data center is designed with a modular approach, then cooling and power infrastructure can be added to the data center when it is needed, and not before, thereby reducing the risk of stranded assets. Further, by designing the space for its maximum capacity, you can eliminate the potential for costly modifications in a working IT equipment environment.

Designing for phased growth may only add a small cost up front, but reduces the risk for much larger costs in the future. On the cooling supply side, an example of this method would be to include capped piping connections to future chillers, and the necessary valves to support its installation. On the cooling delivery side, this could mean capped piping connections and associated valves to support additional CRAH units. The design should ensure that the entire system can be operational while this additional capacity is installed, although this may already be the case for maintenance purposes.

Depending on the design of the data center, the methods by which growth can be planned for and accommodated may be vastly different, and yet the concept remains the same. In an older data center with simple

perimeter CRAC units, this could mean being able to ultimately double the number of CRACs in the space by having the provisions for that future equipment. With other forms of close-coupled cooling, the additional provisions might be additional taps on the cooling piping in the IT equipment rows. And finally, in a data center that embraces liquid cooling of servers, this might mean something completely different.

In all cases, the idea is to plan out the growth and/or contraction of IT equipment and subsequent loads. By doing so, there are means to improve the costs and the energy performance over the life of the data center.

Air Distribution Methods

Historically, there have been two main methods of air distribution within the data center (underfloor or overhead). Despite their differences there are long-standing best practices that can be applied to both.

Beginning with raised floors, the concept of distributing cool air throughout a data center by using a raised floor to create an underfloor plenum is old news (aka, raised floors). The system can be reasonably efficient and offers additional benefits such as the ability to route piping or electrical distribution throughout the space as well. Raised floors still commonly exist in old and new data centers alike, so there are best practices that can be applied.

For new and old designs, the amount of airflow vs. the raised floor height is an important consideration. The raised floor height can be a limiting factor for the ultimate power density of IT equipment that can be supported. The combination of floor height, blockage due to piping, conduits, structural supports and bracing, etc., distribution of IT equipment above the floor, type of perforated tiles, and available static pressure at the HVAC equipment are all factors that must be weighed and considered.

Based on significant study and modeling, several ASHRAE publications have recommended, as a best practice, to have at least 24 in. (609 mm) of height (that is clear of obstruction) within the raised floor for optimal and even air distribution. Shorter plenums are subject to variations in pressure distribution including causing reverse airflow through perforated tiles in areas of particularly high air velocity (velocity pressure greater than static pressure).

For overhead systems, many of the same principals and tradeoffs exist; keep the maximum static pressure

required low. Other considerations such as supply grille airflow direction and throw, as well as mounting height from the IT equipment must be carefully planned out.

Setting up the system to accommodate scaling results in several tradeoffs.

Moving forward, whether using overhead or under-floor air distribution, achieving energy efficiency through good static pressure management will remain an important consideration.

Localized Cooling

One of the ways that some state-of-the-art data centers are managing to be more energy efficient is to use localized cooling or close-coupled cooling. By capturing the heat produced by the IT load as close as practical to the source, it allows for heat loads to be transferred more energy efficiently. These systems commonly use a liquid as the transportation medium to disburse throughout the data center.

Examples of localized cooling solutions include in-rack heat exchangers, in-row heat exchangers, or rear-door heat exchangers. Each shortens the path that heat takes to be removed from the data center, but each solution requires specialized hardware, additional piping, and may reduce the overall flexibility on the data center floor. The energy efficiency occurs by removing the fan power required to move large amounts of airflow, including the inefficiency of the airflow mixing that occurs.

These solutions can be used either in place of a traditional cooling system, or to augment them, such as in a data center with CRAC units supplying air via a raised-floor but with rear-door heat exchangers on the racks with the highest loads. By targeting only the most concentrated heat loads, large efficiency gains can be achieved for a reasonable initial cost.

For now, localized cooling solutions are mostly used by specialized data center loads, enabling either high efficiency or assisting in the cooling of particularly high loads. However, the variety of available localized cooling products grows each year. As server and rack densities continue to push higher and higher, so do the potential benefits of these solutions.

Energy and Performance Management

Properly managing the behavior and performance of all the equipment within the data center is yet another

best practice. Too often, data centers are designed, constructed, and then run according to their initial design. Yet, the IT equipment within the space changes. As a result, the performance of the HVAC equipment can change over time and a whole host of other conditions can change on a short or long-term scale. Not properly adapting the behavior of the data center to the changing environment will invariably yield inefficient performance, and possibly even malfunction.

One example of this management involves balancing of routine and adaptive maintenance. Routine maintenance can consist of cleaning or changing air filters, servicing chillers, or exercising and testing backup generators. Most manufacturers prescribe a specific maintenance plan; however, it should be adapted for the local conditions. For example, perhaps exterior air filters should be cleaned more regularly during a particularly pollen-laden spring, or perhaps CRAC filters should be cleaned after any retrofit or IT refresh activity within the data center.

Neglecting the adaptive component of maintenance can easily degrade the effectiveness of data center equipment. The adaptive component considers the large changes in the IT equipment loads (up or down) and the variability of those loads. Each of these can change the cycling of the HVAC equipment and subsequently change the approach to the maintenance intervals, process, and functions.

Another example of proper management is using a control system that ensures that the data center is working as a single machine towards a single goal. One frequent violation of this occurs when a data center uses CRAC units, each with their own humidification control, without a central control system. CRAC units are often found to be fighting each other, with some humidifying and others dehumidifying the space, each operating based on their own localized sensors.

This results in an obvious inefficiency that could be eliminated by a common control. Even if system had been properly tested and balanced for the initial IT load, changing conditions within the space can rapidly throw off the delicate balance.

A final example of proper management is to consider the holistic impact of any changes made to the data center design. For example, as most people now understand, IT equipment can be run reliably at much warmer entering temperatures than were initially thought. The average temperatures found in data

centers 10 or 20 years ago is much cooler than many today. To this point, some state-of-the-art data centers might even be considered hot by historic standards or comfort cooling requirements.

However, simply turning up the temperature of the data center environment can be disastrous. Dialing back the CRAC fans to accommodate a higher temperature may trigger the IT equipment fans to run harder, and the energy consumed by smaller inefficient fans may completely offset the reduction in CRAC energy usage.²

Looking forward, the integration of controls systems, increasing numbers of facility sensors, and sensor data from onboard IT equipment should make it much easier to truly manage a data center environment holistically. The collection and aggregation of sensor data that is possible today is so far beyond what was possible just five years ago, and widespread efforts continue to push towards a “smarter” data center.

Conclusion

Although the IT and data center industries change very

rapidly, some of the data center best practices are the ones that have withstood the test of time. This is because they focus on universally important concepts like efficiency, changing conditions, and the future.

Planning for IT equipment load changes, implementing air management best practices (hot/cold aisles and static pressure management), using localized (close-coupled) cooling solutions, and using adaptive maintenance routines, as well as improved control strategies are all part of the long-standing best practices that continue to apply to many data centers today.

Although new IT equipment and HVAC systems and solutions may be invented that supplant older ones, the logical foundation on which these best practices are based is not likely to become irrelevant any time soon.

References

1. ASHRAE. 2008. *High Density Data Centers: Case Studies and Best Practices*. Atlanta: ASHRAE.
2. Patterson, M.K. 2008. “The effect of data center temperature on energy efficiency.” *11th Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems*. ■

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