accenture Dialogue online The news source for Accenture people

High performance. Delivered.

Interview with an Expert: X-nth – Trusted Advisor to the Mission Critical Industry

Interview conducted by: Rami A. Rihani, DCT&O United States

The Green Data Center Community of Practice is delighted to interview Mr. Ed Koplin, PE who is a Principal in X-nth's Mission Critical line of business. Mr. Koplin has more than 26 years experience in data center electrical and mechanical design. He is also responsible for the design of critical systems and equipment specifications for data centers. His experience includes the design and commissioning of critical central plants, co-generation systems, critical power generation, chilled water, heating, heat rejection, and associated automation and monitoring systems. He also brings extensive experience in live renovations of mission-critical facilities.

Q: Just to level-set the Accenture audience, could you provide some over-arching concepts for Green Data Centers?

A: I believe that "green" can be a mixed message that becomes difficult to manage or measure. Green relates to new construction as well as existing building operations. New construction, or sustainability, as it relates to using local/recycled materials, LEED and implementing alternative energy sources. Green also has its roots in the energy optimization of existing data centers. New construction metrics apply to only a small fraction of the industry and there are no guarantees that a new data center will operate efficiently. There is a need for the IT industry to set guidelines for new data centers, however I would like to focus this interview on the opportunities to optimize the energy repercussions of IT deployments in existing sites. Coordination and integration with facility operations will be essential.

Really, the goal for existing data centers should be to reduce energy consumption, or at least know that utility costs, however high, represent optimized, integrated energy efficiency. Unfortunately, the compaction of space required by IT hardware has resulted in unprecedented increases in power and cooling, out-stripping facility infrastructure, design standards and space allocations. "Back of the House" spaces for power and cooling to support high-density computing are now larger areas than the computer area itself. This design dynamic presents a distressing problem for data center operators, because without power and cooling, there is no data center. It can be discouraging to find out that more than half of the building area allocated for a data center is required for fault tolerant, maintainable power and cooling.

Within the last 10 years, this predicament has reached tremendous proportions. Trade journals, news media and IT industry watch groups such as Gartner Group, AFCOM, BISCI, ASHRAE, Uptime Institute and others, have published daily examples of system failures, inefficiency, high utility costs, over budget construction and growing dissatisfaction in general. Maintenance and operation of the complex electrical and mechanical systems are now one of the leading causes of critical load disruption; the trusted maintenance vendor pushing the wrong button, turning the wrong valve, throwing the wrong switch. Confusion results from the best design and construction efforts resulting in unreliable performance and poor energy efficiency.

The three key issues associated with this conundrum are:

1. Power and cooling standards are driven by the broad real estate market life-safety issues related to occupant injuries. Data centers represent less than 1/10 percent (0.1%) of all real estate construction in the United States. Additionally these are lightly occupied or unoccupied buildings. Some are actually "lights out" facilities that are fully automated, without any occupants.
2. Corporations, universities and governments focus their fiscal responsibilities on the largest budget items. In a data center environment, annual facility costs, including infrastructure depreciation can be less than 0.5% (1/2%) of the IT budget. In a large transaction company, the costs to operate and maintain the electrical and mechanical infrastructure may be 1/1,000 of a percent of the company's annual revenue stream…less than rounding error. Stakeholders may be interested in "green" but the costs are too small to capture upper management attention.
3. Data centers may be small areas located within a much larger building, camouflaging the true operational risks and utility expenses. In a multi-use facility, many of the costs relating to the data center may be buried in the operating costs of the larger host building, even though the costs for operating the data center may be one-thousand times the costs of equivalent office space or call center. For example, an international pharmaceutical company recently migrated a 1,000 SF, high-density server room into their 50,000 SF office building. The utility bill for the facility

doubled! It has remained twice the prior year for the past nine months. In a much larger facility, the costs may not have been attributed to the small, high density data center.

As a result of these persistent issues, the facility infrastructure support for higher levels of processing is short-changed because data center infrastructure represents such a small portion of the real estate market, and because the finances relative to the revenues are small. Thus, the data center conundrum.

Q: What do you see as some of the major obstacles to overcome, when attempting to implement energy conservation strategies?

A: The number one obstacle: perverse incentives. Data centers by definition are mission critical. Keeping the data center continuously available is the mission. Cost containment, even it imposes a little bit of risk is shunned. Thus, facility operations staff are encouraged, even rewarded for uptime metrics, even at the expense of energy consumption and costs. Certainly, it isn't rocket science to run everything at once, including redundant electrical and mechanical components to ensure sufficient capacity exists during an unexpected component failure. A facility operator who attempts to implement an energy-saving strategy that inadvertently causes critical load to fail, or *it is perceived that the strategy caused the load to fail*, is an ARG (Automatic Resume Generator).

Second, and maybe more insidious, is the perceived control that IT hardware manufacturers have over the built environment. Their narrow range of "recommended environmental conditions" requires vast amounts of energy. While our IT industry wrings their hands and agonizes over the temperatures and humidity "necessary" to protect sensitive IT equipment…also read maintain warranties… other mission critical industries have overcome the same challenges for decades. High power density electronics, continuous availability and diverse, even harsh operating conditions are a staple in the broadcast and telecommunications industries for example. Procurement in these industries wisely sets the environmental and emergency operations standards for their manufacturers, not the obverse, as we see in the IT industry.

Mission critical, high power density radio and television systems operate continuously on the tops of mountains and at the bottom of valleys, in deserts and in forests. Stringent vibration, temperature and humidity tests are imposed on a manufacturer's offerings, *before they are purchased*. For example, Central Office telephone equipment is expected to operate in the middle of an earthquake, during a fire. Why do we continue to coddle the manufacturers of data center equipment who claim to also be in a "mission critical" industry?

In summary, by opening up the environmental window for data equipment, energy consumption is reduced. In some geographic areas entire mechanical systems can be eliminated, if temperatures and humidity in the data center are acceptable over a wider gradient.

Q: What new designs concepts are you advising your clients on in regard to High Performance Computing Centers (HPCC)? What are some of the new ideas on tackling data center energy efficiency?

A: Data Center facilities need to go where IT is going. Flexibility, aka, Future-Proofing, is essential since the electrical/mechanical systems have a life-cycle of 15 to 20 years. Over that time a client may have up to 10 migrations of computer hardware.

Specifically, X-nth is encouraging our clients to specify higher voltages for their computer hardware. Our facility designs typically contain the necessary components to provide water-cooling or air-cooling to IT equipment simultaneously. For example, in 1995 the back bone of any large data center was water cooled mainframes (IBM ES-9000, Hitachi Skyline, etc.) By year 2000 all IT hardware was air cooled. Additionally, the water cooled mainframes used higher voltage power, typically 480 volt, 3-phase. By 2000, power distribution dropped back to 110/208 volt, single-phase power.

Today, we are heading "back to the future." High density, high performance computer systems require higher voltages to reduce wire sizes and most manufacturers are offering water-cooled solutions for their high performance product lines. Expect HPCC environments to look a lot like the mainframe data shops of the 90s. Clients who allowed their infrastructure designs to be narrowly focused lack sustainability.

The most expensive cost, and simultaneously least "green," initiative in a long-term IT program is to abandon a functional data center that cannot support next generation requirements.

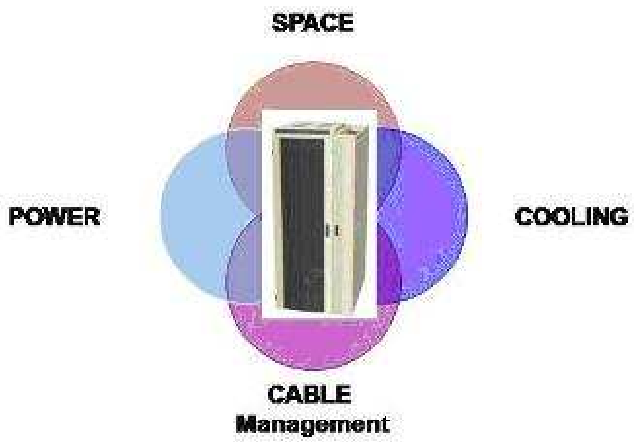
Cross-functional thinking as promoted by Gregg Rudinski, Executive Director for Morgan Stanley, has expansive benefits for the energy performance and sustainability of a data center. Facility construction is a small fraction of IT program costs, but CIOs generally have little control of the budget, design or construction details associated with their IT mission. Seemingly, incidental construction costs, may be "value engineered" out of a project, only to become a strategic necessity a few years later. Moving or migrating the network, because of building limitations, can be a staggering cost and have a very large environmental impact. Best practices involve collaborative efforts between the CIO's program and facility options; pennies on the IT dollar. Mr. Rudinski added that the IT and Facilities professional disciplines needed to unify around the data center issues. This unified approach will be better able to meet the new challenges brought on by the developments driven by virtualization and cloud computing.

On a number of recent data center projects, the IT department was invited to construction planning sessions. They learned that their procurement practices could enhance the operability, flexibility, efficiency and longevity of their data center. Here are some low cost/high benefit decisions that were made:

1. Purchasing their larger IT systems in higher voltages. UPS power was distributed directly to the IT equipment, eliminating transformers. Useable space increased on the raised floor, energy efficiency improved by 3 to 4%, electrical installation costs were saved and reliability was enhanced. All of these significant benefits were provided, without any increase in the IT budget, simply because IT procurement was integrated with facility design.
2. Computer enclosures, typically procured *after* data center construction, were specified *during* the data center design process, procured during construction and installed by the electricians. All of the raised floor perforated tiles were eliminated! The enclosures were integrated into the facility design, coordinating cooling, power and cable management in a high density environment. IT manufactures will need to comply with the facility environmental and data center enclosure standards. Energy efficiency was optimized and a standard operating environment was created. Construction costs were increased by IT budget transfers for the cabinets, *but costs for the distribution of power, cooling and cable/fiber were dramatically reduced* by coordinating those efforts during the construction process, not after the fact.
3. In cold weather environments, cooling towers become a giant, single point of failure due to freezing. Discussions with data center maintenance staff and detailed testing during freezing weather resulted in the design of a freeze-proof cooling tower system. While using water and an evaporative process, freeze risks were totally eliminated without energy for heating piping, using insulation, anti-freeze or unreliable, automatic controls. Green and Mission Reliability were merged cost effectively.

Q: How about this new push to eliminate the hot-aisle cold-isle floor layout?

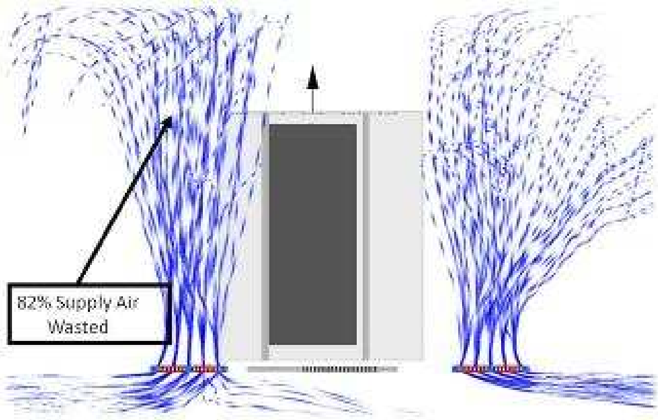
A: I have been publishing on this topic since 1995 through the ASHRAE Handbook on High Density Design in 2007. Traditional design, with hot/cold aisles, perforated tiles and ventilated cabinets originated in 1985. Extensive testing in actual raised floors proved that the concept is only effective and somewhat efficient up to cabinet power densities of 3kW. Modern data centers have power densities up to 100 kW per cabinet. All data center resources converge at the computer enclosure. Understanding, testing, and modeling the coordination of power, space and cooling at the enclosure is essential for optimizing energy conservation.



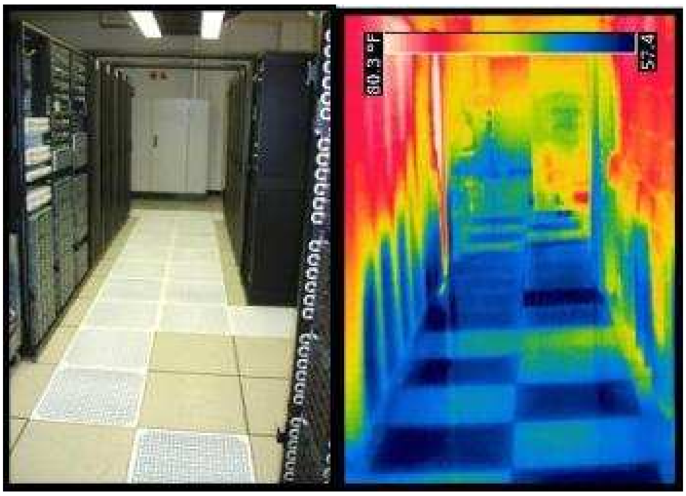
All data center resources converge at the computer enclosure

Making the invisible visible is the benefit of empirically validated CFD (computational fluid dynamics). The figure below is an example of a 23 kW server cabinet supported by hot/cold aisles and perforated tiles. Over 80% of the cold supply air delivered to the server cabinet was wasted. Three facts emerged from this study:

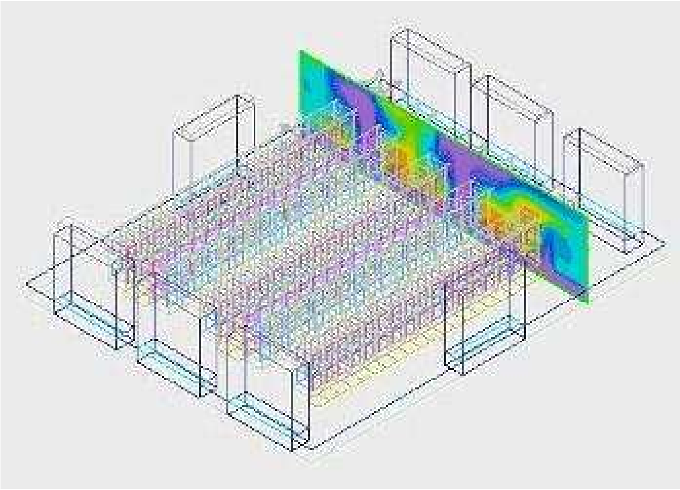
1. The raised floor tile product, quantity and placement were specified by the manufacturer of the server.
2. The hardware manufacturer supplied a cabinet that lacked inlets adjacent to their recommended placement of the majority of the tiles.
3. Even though the manufacturer's design wasted 82% of the airflow, their engineers insisted that the data center wasn't providing sufficient airflow! Unfortunately, the Owner, realistically concerned about protecting the warranty, left the installation as specified, *despite the wasted energy and cooling limitations imposed to adjacent areas of the data center*.



Cooling Waste in Super Server Installation - Empirically validated CFD model of a manufacturer's recommended placement of perforated tiles



Upper servers clearly overheating. Hot computer exhaust air is re-circulating from the hot aisle behind each cabinet in hot/cold aisle design

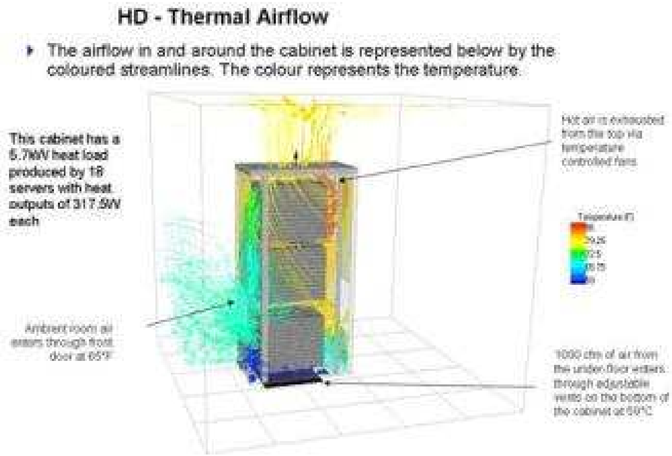


CFD model of an existing hot/cold aisle installation displaying re-circulation of hot exhaust into the cold aisles

A number of Innovations are superseding the hot/cold aisle standard. Some of these solutions however are "bleeding edge." Implementation requires ceiling space that interferes with life safety, lighting or structured cabling. Others are very expensive, or require additional areas within the building, that may be unavailable for supplemental support systems. Drop-in, cost effective, energy enhancing concepts have matured in the area of computer enclosures. A number of hardware independent cabinet manufacturers have perfected systems that speed data center migrations, enhance power and cooling distribution and reduce energy costs.

Power Use Efficiency (PUE) is a generic benchmark that measures the ratio of total energy to the data center with the energy delivered to the computer equipment. PUE's are theoretically limited since power quality conditioning and mechanical cooling need energy. However, in existing data centers, PUE's can be achieved as low as 1.31. Eliminating hot/cold aisles is an important requirement to achieve the energy conservation improvement. New construction may be able to achieve better PUE's, but existing facilities have cost, space or risk constraints. The highest bang for the buck however involves simple replacement of the enclosures and removing the perforated tiles in hot/cold aisle installations can be very cost effective. In one case, we have seen a 19.4% PUE improvement (from 1.76 to 1.42) by upgrading to this relatively risk free concept.

This figure below is an example that uses CFD modeling to display the active thermal management to support computer loads. Hot/cold aisles are eliminated. Efficiency is improved. In recent years, a number of computer enclosure manufacturers have developed solutions to migrate away from hot/cold aisle designs.

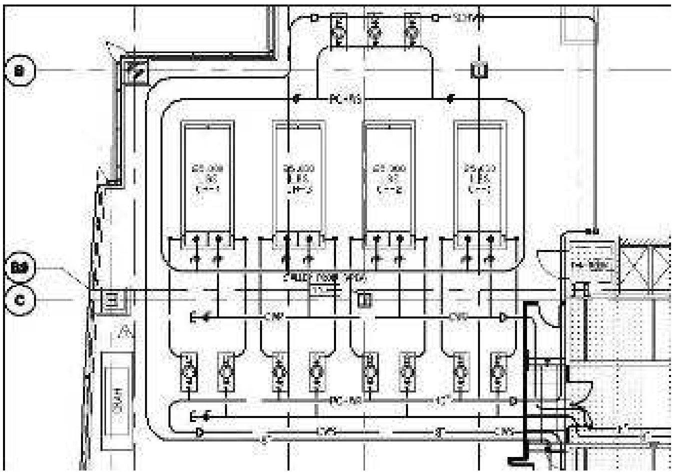


High energy efficiency by using the cabinet design to coordinate power and cooling.
Courtesy of AFCO Systems (www.afcosystems.com), Farmingdale, NY

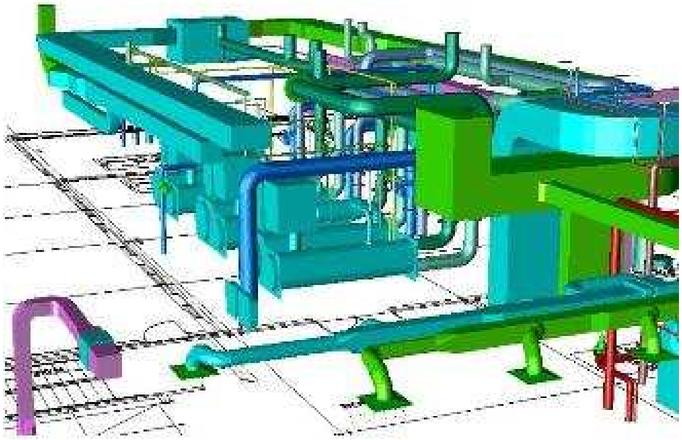
Q: What are the data center design best practices that X-nth adopts with its clients?

A: Three-Dimensional computer aided design has transformed our consulting practice. Eight years ago we developed the training modules for three-dimensional drawings in all of our disciplines. As an extension of those initiatives, our design teams provide the native electronic design files to the various trade contractors on our data center projects.
Using the 3-D drawings, each trade can coordinate layering schemes, access requirements, schedules and costs to avoid collisions in the field. In construction parlance, the "shop drawings" are created and validated *in advance of actual construction*. The collaboration of the contractors, with our design engineers is exhilarating. As a team, we meet to discuss conflicts, prior to construction, on virtual, 3-D drawings that are accurate within ½ inch (12mm).
Change orders and delays are avoided and the contractors can focus on quality workmanship. Despite popular opinion, we find that contractors would rather have excellent coordination in the drawings and complete their work per the original scope, rather than delay construction to issue change orders throughout the project. Recently, two of our data center designs were selected for craftsmanship awards. We like to think that the contractors on those projects enjoyed the drawings and specifications they had to work with.
Computational Fluid Dynamic (CFD) modeling assists our design teams with placing computer equipment where it will be best served by the mechanical plant. A 7-year study for one of the largest financial companies helped our design teams empirically validate the CFD models. Teams were sent to the data center to collect data from the live data center and use it to calibrate the CFD models. Eventually, we were able to create a Virtual Data Center for our client whose operational attributes modeled the actual data center within 36 inches (1 meter) of our test points. Various hardware migrations, operating set points and mechanical configurations could be modeled on the CFD *prior to actual computer systems being installed*. The data became the benchmark for an entire generation of design standards published in 2007.

Over 350,000 square feet (30,000 square meters) of raised floor was designed for this client, around the world, using these new standards. We strongly recommend the use of empirically validated CFD models, in the data center programming effort. These models, once approved, are used to develop the detailed design and 3-D drawings for the site.



Traditional 2-D design drawing



3-D design drawing of the same facility

About X-nth: Established in 1967 with corporate head quarters in Orlando, FL and eight additional offices across the United States, X-nth is one of the top 10 US Building Systems Design firms with a Federal and Fortune 500 client base. Active in publishing research and industry standards (their team was involved with the development of the initial Uptime Institute data center tier structure), they are considered one of the top global data center design firms. X-nth's comprehensive service structure specializes in strategic planning, concept design, construction design, and integrated commissioning. Their home page is www.x-nth.com

November 2009