



DBBC

Demand Based Cooling™

Cooler Servers with Less Cooling

A White Paper on the Results of Using the
AdaptivCOOL™ Demand Based Cooling System

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Cooler Servers With Less Cooling

Physics dictates that keeping servers cool requires a certain amount of CRAC (Computer Room Air Conditioner) capacity. Intuition suggests that providing additional cooling would reduce server temperatures even further. As is often the case however, too much of a good thing can be bad. While it is commonly known that mixing is the bane of efficient cooling and items such as blanking panels, floor closures, hot/cold aisle are effective, less well known is that mixing has another dimension – under the raised floor. This case study illustrates the negative effects an unbalanced cooling load can have and offers a solution to the problem.

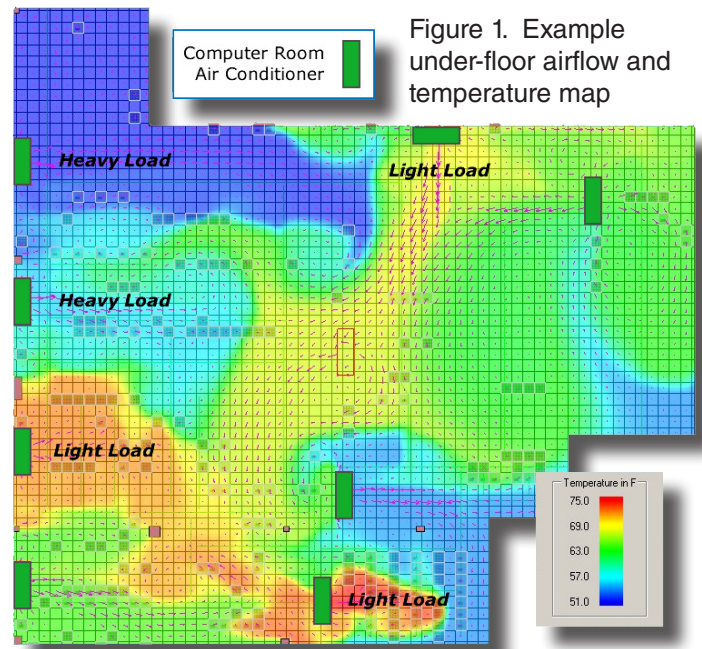
Many data centers supply cooling far in excess of what is required or have problems distributing cooling where it is really needed. The Uptime Institute™ for instance conducted a study that pegged cooling at an average of 2.6 times what was required; the most over cooled sites often had the worst thermal problems. The most often cited cause for such inefficient cooling is a phenomenon known as mixing. Cool and warm air mix before entering server intakes and again before CRAC returns. Recent

studies from various industry groups agree that managing airflow and reducing mixing can cut data center cooling costs dramatically and even eliminate the need to build new sites. Commonly when mixing is discussed, such things as cable cutouts, blanking panels and hot aisle/cold aisle rack layouts are considered. These are all visible out on the server floor, and in most cases beneficial.

A far less considered, but equally important, component of mixing is the interplay between the computer room cooling units, server rack heat loads and under-floor air distribution. The area under the raised floor is hidden from view and often mistakenly considered to be a relatively constant pressure and temperature. Knowledgeable Data Center professionals know that pressure can vary greatly. Less well known is how widely temperature can vary under the raised floor and why. This temperature variance is yet another form of mixing and can

negatively affect server room cooling.

The site for this study was typical of many data facilities in that it had redundant cooling units running 24x7. Therefore many of the computer room air conditioning units were turned on but not being asked to provide much cooling. The unintended



side effect of this condition was that some of the CRACs were injecting vast quantities of relatively warm air under the raised floor. The under-floor temperature map (Figure 1.) illustrates this phenomenon.

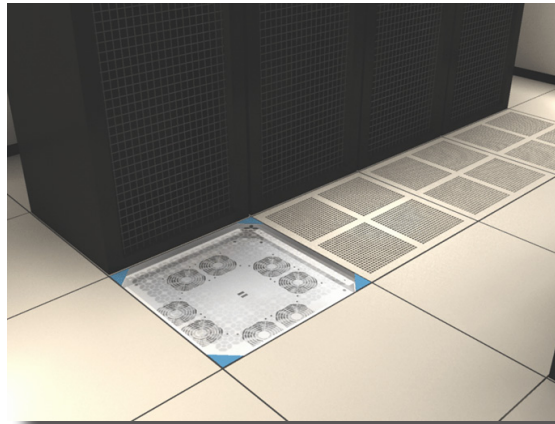
As can be seen, cooling

units that are lightly loaded are causing warm air to be supplied to the under-floor, while units that are heavily loaded are producing prodigious amounts of cold air. At first glance this may seem to pose little problem, if there is low heat load in an area, there is no need to provide large amounts of cooling to that location – Right? In reality there is often a disconnect between above- and below- floor zones of influence for individual cooling units. Air is lazy and follows the path of least resistance. This means a CRAC can receive return air from one portion of the data center while supplying the bulk of its under-floor air to another portion. This can create an imbalance and can result in higher server temperatures. Adding more cooling just makes the problem worse.

The obvious solution would be to simply turn off the lightly loaded CRACs. This poses several problems however. First, excess units are often being run as a redundant backup in the event of a cooling system failure. Without a way to turn a unit on immediately there is a risk if one of the primary CRACs fails. Secondly, the under-floor pressure is affected by turning CRACs off; there may not be enough pressure

to force adequate CFM through the perforated tiles in some areas. Thirdly, air is lazy; the return air paths are affected by which cooling units are running. Turning off redundant cooling will cause an increase in some server temperatures and possibly a reduction in others. The Data Center's temperature profile will vary depending on which CRACs are shut off, making manual management of this activity tricky to orchestrate.

Figure 2. Under floor air-mover placed under a perforated tile



To make things even more difficult, today's dynamic IT loads make manual control even more fraught with pitfalls.

A solution to this dilemma is to provide close-coupled variable airflow to the server racks, and then intelligently control the CRACs to right-size the cooling capacity. This allows racks to use just the cooling they need and the excess cooling to be put in a "Hot-Standby" mode. The expected benefits are reduced energy. In addition,

there is less mechanical wear on the infrastructure components. A surprising benefit is the IT equipment is cooler! The method used at this site to accomplish this is AdaptivCOOL's Demand Based Cooling; which consists of an intelligent network of sensors, air-movers and intelligent control of the CRACs. Unlike other close coupled solutions; it requires no servers or racks to be moved, no liquid of any kind and works with the existing infrastructure.

Key components of the solution are under-floor and above floor air-movers strategically placed to dynamically manage airflow. The illustration in Figure 2., shows the placement of an under-floor air-mover in front of a server rack. These are strategically placed based on the results of CFD analysis.

With the ability to provide dynamic close-coupled cooling to the racks and eliminate airflow distribution problems; cooling throughout the room is optimized and cooling capacity can be right-sized. There is much reduced mixing both above and below the floor. An added side benefit to right-sizing the number of cooling units is higher Delta-T which translates to higher efficiency and less dehumidification. Of course, enough cooling must be kept online with some small

buffer. With under-floor air-movers, the actual source of cooling to a rack no longer needs to be from the closest CRAC. Conversely, overhead air-movers can redistribute or evacuate hot server exhaust to a hungry CRAC return.

Results at this site are shown in Figure 3. The site netted an average server temperature decrease of 4°F, with 1/3 fewer CRACs online. The effect was verified repeatedly to insure there was no time of day influence.

This is counter-intuitive so it is useful to further explain the contributing and reinforcing factors at work here.

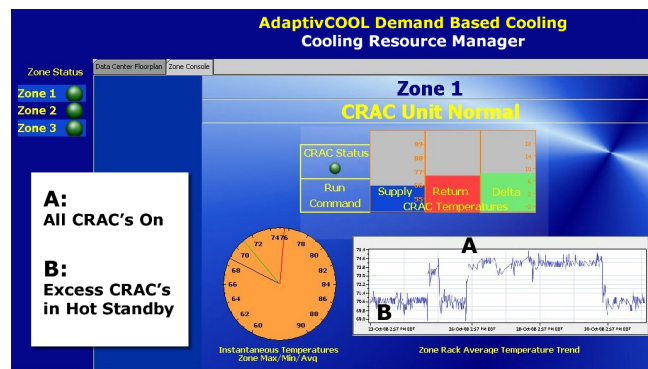
Let's first briefly explain Delta-T and its effect. Delta-T for a CRAC, simply expressed, is the difference in return and supply temperature. It is greatly influenced by the heat load or total BTU's being returned in the air and much less so by the CRAC setpoint. The Delta-T of a cooling system largely defines its useable capacity and efficiency. CRACs that are highly heat loaded are at a high Delta-T, run efficiently and produce their maximum amount of cooling. Conversely CRACs that are lightly heat loaded run at a lower Delta-T, lower efficiency and produce less cooling.

Using active air-movers at key rack locations insures that cooling supply to the racks is right-sized. In addition, active air-movers fix inherent distribution problems that previously relied on CRAC over-supply. Varying combinations of CRACs can now be put in standby without greatly affecting airflow to the racks.

The remaining CRACs at higher Delta-T deliver colder AND undiluted air to the under-

higher Delta-T and less latent cooling at the CRACs. 1/3 fewer energized CRACs means less wasted Fan HP. The entire project was completed without a single server or rack being moved and without any changes to the infrastructure. In addition to achieve this efficiency no hot or cold aisle containment strategy and the attendant fire safety issues were required.

Figure 3. Data Center Dashboard: Servers run 4°F cooler with 1/3 of CRACs in Hot standby.



floor. Further, since there is less over-supply of air, the amount of mixing above-floor is reduced. This has a reinforcing effect. Virtually all the cold air is delivered to IT rack intakes and then heated; Delta-T is further raised.

Cooling energy savings at this site is 37% as compared to its baseline. The savings comes from a variety of factors. Reduced mixing both above-floor and below-floor allows