Questions and Answers on Data Center Cooling Issues

Q. *I have plenty of cooling capacity, so why is my file-server area unevenly hot?*

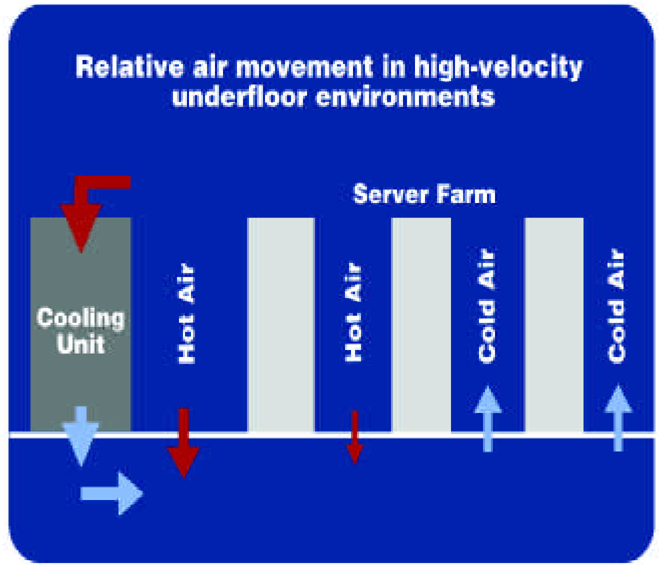
A. Uneven cooling is a very common problem that is likely to get much worse as server-farm power consumption rises due to increased rack heights, more equipment within racks, and increasing (not decreasing) equipment power consumption. Depending on heat density and computer-room configuration, forensic mechanical engineering may be required to holistically identify all contributing problems, then solutions are pretty simple to specify.

Q. *How can I get more airflow through equipment racks?*

A. This cooling problem deals with the way cooling air gets into the equipment rack. Equipment racks with perforated skins that allow free air movement work the best. Racks having solid fronts may look nice, but solid, nonperforated skins allow very slow heat transfer and permit interior temperatures to climb above 104°F. And data shows that for every 18°F (10°C) increase in temperature above 68°F (20°C), long-term hardware reliability is decreased by 50%.

Q. *Hewlett-Packard has recently introduced a major product family called Superdome. What impact will this new generation of products have on my data center?*

A. The power consumption for this new generation of servers (formerly called mainframes) is much higher than for previous generations. All the major manufacturers either have or soon will have similar products with power consumptions ranging from 10 kW to 20 kW per frame. Many sites will have problems cooling even small quantities of this generation of computers using traditional mechanical engineering approaches. The amount of air delivered to the frame from the underfloor will become critical. Air dams need to be removed and inappropriate openings in the raised floor must be closed to increase static pressure.



High-velocity cold air leaving the Cooling Unit initially draws hot air down into the underfloor. As underfloor air velocity decreases away from the Cooling Unit, cooling air rises through the perforated tiles. Full cooling effect may take place as much as 30 feet from the Cooling Unit.

Q. *Does any particular arrangement of the equipment racks have a positive or negative effect on equipment reliability?*

A. Look at how the equipment racks are physically oriented on the raised floor. In over 75% of sites, racks are typically arranged so they all face the same direction. This arrangement is a significant cause of cooling-capacity problems, because the hot-air exhaust from one row of racks becomes the cooling air intake for the next row. This is not a good environment for computer-hardware reliability and will eventually result in premature and seemingly unexplainable failures.

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Q. *I have the computer equipment right in front of an air conditioning unit and the equipment is still running hot. How can this be?*

A. It seems counterintuitive, but equipment placed too close to an air conditioning unit can actually run hot because no cooling air is available at that point. Static pressure in front of cooling units is very low because the velocity of the air coming off the fan is very high. In fact, the velocity may be so high that hot return air from above the raised floor is being sucked down into the subfloor plenum. High heat load equipment should be placed far enough away from the source of cooling to ensure proper airflow through the perforated tiles. Sometimes this spacing can be as much as 30 feet.

This cold aisle shows proper placement of perforated tiles on the intake side of IT equipment, but solid-front doors may be impeding the intake of cooling air. This site may experience problems as product heat densities rise.

This hot aisle on the discharge side of IT equipment should literally be hot. Perforated tiles improperly placed in the hot aisle reduce cooling effectiveness.

Q. *Should I put perforated floor tiles at the exhaust side of my computer equipment to help cool the room? The temperature of the air out of the racks is too hot.*

A. No. Perforated tiles do their best job when placed on the INTAKE side of the computer equipment. This position provides the equipment with the best operating environment. The exhaust air temperature is not a problem if the air going into the computer's intake is at the correct temperature. Placing perforated tiles on the exhaust side of equipment pre-cools the air returning to the air conditioning units.

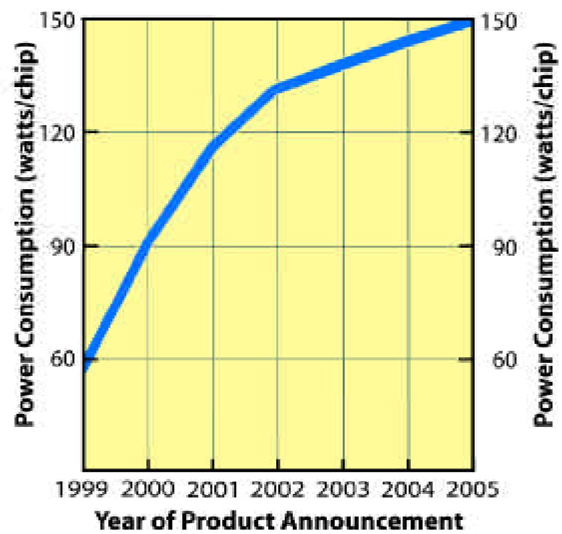
When the colder return air is received back at the air conditioning unit, the controls will throttle back on the amount of cooling provided. This adjustment often results in hot spots in the highest heat load areas of the computer room, which can adversely affect the long-term reliability of the computer equipment.

Moore's Law Predicts Steadily Increasing Heat Loads

Q. *Why are data centers having problems with increasing heat loads?*

A. Moore's law states that semiconductor processing power will double every eighteen to twenty-four months. Actual semiconductor performance has closely held to this 1965 prediction by Gordon Moore (one of the founders of Fairchild Semiconductor and subsequently of Intel). Semiconductor manufacturers estimate the doubling relationship will hold at least through 2005. According to this principle, a high-end processor in the year 2005 will be one million times more powerful than its thirty-five-year-old predecessor. This exponential increase in processor capacity has allowed the development of the Wintel processing architecture as a full-fledged, viable competitor to mainframe computing.

Microprocessor Power Consumption Trends



Source: Semiconductor Industry Association 1999 International Technology Roadmap for Semiconductors

One of the side effects of continuously increasing processor capability has been the shrinkage of the computer hardware required to perform a fixed volume of work. Over the last thirty-five years, this rate of footprint reduction has reached 30% annually. This shrinkage (called technology compaction) means the amount of physical space required to accomplish a set volume of Information Technology (IT) work (measured in constant units of processing and storage) has been declining continuously. If a site upgraded their technology with state-of-the-art equipment every year, they would experience this 30% decrease in floor space annually; however, most facilities do not replace hardware this frequently. Instead, floor space consumed remains constant or grows until an entire generation of technology is replaced every two to five years. When this replacement occurs, a dramatic amount of white space can result if business volumes and new applications have not grown substantially enough to require more boxes of processing equipment.

Technology compaction has not been accompanied by parallel reduction in electrical power consumption. Instead, power consumption per processor has remained the same or even increased as computing ability has grown. Over the last two years, power consumption per most powerful chip available has practically doubled, growing from 60 watts/chip to 118 watts/chip. The power consumption of future microprocessors is expected to grow to 150 watts/chip by 2005.

If space consumption is falling at the rate of 30% annually, but power consumption per processor is constantly rising, the power consumption over the product footprint in watts/ft^2 must also be rising. And indeed this increase is taking place. Over the last decade, the combined effect of Moore's law and technology compaction has been a 17% annual increase in the density of power consumed and heat dissipated by IT products.

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Q. *For maximum cooling, what is the best location of the perforated floor tiles in relation to equipment racks?*

A. If the only cooling air available is through the cable cutouts at the back of the rack, cooling inside the rack will be marginal, and the ambient temperature will increase significantly from bottom to top, especially if solid-skin front covers are installed. Perforated tiles need to be located in front of the rack (on the cold aisle) where they can provide cooling to the air-intake side of the servers installed in the rack.

Q. *How can I check for proper air velocity and pressure in the plenum under the raised floor?*

A. You can easily identify the presence of an air velocity problem in minutes using a *HotSpot Troubleshooter*™ available from Computersite Engineering (505-982-8300). This simple card is designed and calibrated to reveal which areas of perforated tile are supplying sufficient air and which perforated tiles are not. If the under-floor air is moving too fast, you cannot get enough cooling air to come up through the perforated tiles. In fact, if the air is moving sufficiently fast, air from above the raised floor will be sucked down into the plenum. In many many instances, no cooling is available within fifty feet of the computer-room cooling units due to high under-floor air velocities. These areas are obviously going to be very hot. ■

The HotSpot Troubleshooter

The troubleshooter card floating above the raised floor indicates an ideal airflow condition (top photo). The card being sucked down against the floor tile (bottom photo) indicates an air velocity problem.

To use the HotSpot Troubleshooter, simply place the card on the raised-floor surface above perforated floor tiles, sequentially testing different locations within the computer room. If the card floats at least 1/2" above the tile surface, air velocity is not a problem. If it is sucked down against the floor tile, the air underneath is moving too fast and no cooling can come up. It is likely that many areas will test fine, while the areas with little or no cooling are likely to be closest to the source of cooling. This phenomenon is counter-intuitive, so a "circling the wagons" solution of surrounding the hot area with additional cooling units will actually exacerbate instead of solve the problem.