Data Center Cabling Considerations

May 2007
(Revised May 2008)

Table of Contents

Abstract

Due to an increase in port density and network data rates in the last few years, the management of power consumption and heat load in data centers has become technically and economically important. At present, it is not uncommon to find temperatures as high as 100 °F in data centers. These operating temperatures may not only degrade the performance of applications, but can also cause accelerated aging of the communication equipment. The additional cooling capacity required to maintain reasonable temperatures increases the cost in infrastructure and energy required to run data centers. In terms of power consumption, large data centers are now comparable to small cities, producing a significant environmental impact. Fortunately, it has become clear to the major equipment manufacturers that increasing the cooling capacity is not the solution. Instead, the efficiency of the equipment used to process and transmit information needs to be improved.

This paper analyzes the effect of higher temperatures on the copper structured cabling and recommends best practices to avoid potential performance degradation or even network down time.

Introduction

Growing user demand for Internet applications as well as companies' requirements to process and store more information have created the need for more equipment, higher density and faster data transmission rates. This, in turn, has increased the thermal load in today's data centers.

A recent study[1] revealed that 0.6 percent of total U.S electricity consumption is used to run servers. When the power consumption of cooling and other infrastructure elements is included, the percent of total U.S. electricity consumption increases to 1.2 percent. Virtually all this power is dissipated as heat. In response to this growing heat load in data centers, the United States

Environmental Protection Agency (EPA)[2] and major Information Technology (IT) hardware manufacturers[3] are mobilizing important resources to increase the level of energy efficiency of data centers[4]. Additionally, the Telecommunications Industry Association (TIA) released the 942 standard in April of 2005. Among other things, this standard[5] contains important guidelines for decreasing potential heat build-up in data centers.

In practice, IT professionals designing densely-populated data centers still face many challenges in keeping operating temperatures reasonably low. In fact, it is almost impossible to maintain a uniform temperature throughout a data center. Therefore, it is probable that hotspots will occur.

This paper focuses on specific sources of heat, cooling capacity, actual data center temperature measurements and the influence of elevated temperatures on twisted-pair cabling solutions. Recommendations to minimize the risk of performance degradation are included in this work.

Heat Sources and Cooling Considerations

From 2000 to 2005, worldwide data center energy consumption doubled. Up to eight percent of this increase can be attributed to higher per-unit power utilization. The remaining 92% can be attributed to the increased volume of servers[6].

Since nearly all of the power used by a server or switch is dissipated as heat, a reasonable conclusion is that greater power consumption directly causes an increase in the heat radiated into the data center. Figure 1 illustrates the projected heat load per square foot of data center space.

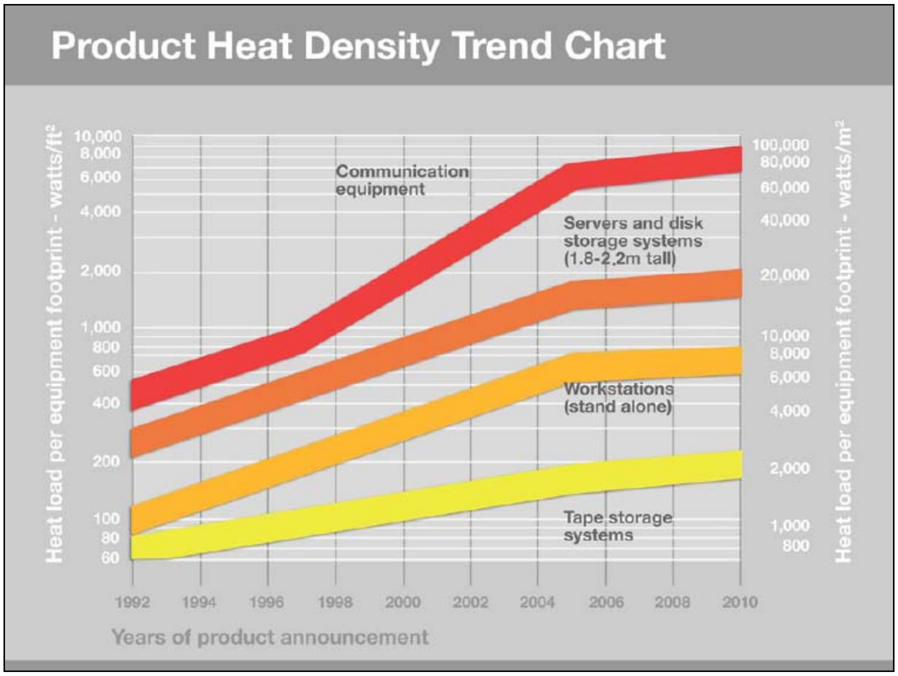

Figure 1: Heat Load per Equipment Footprint[7]

Based on the power spectral density of applications such as Fast, Gigabit, and 10-Gigabit Ethernet, a 100-meter channel of twisted pair cabling was shown to dissipate just a few milliwatts of power. In a data center with a few thousand twisted-pair channels, the heat dissipated by the entire cabling plant will be on the order of a few tens of Watts, a total that is three orders of magnitude smaller than the heat generated by the equipment in the data center. Therefore, it is reasonable to say that the copper cabling plant is an insignificant heat source in a data center. However, it can be affected by the heat being generated by the equipment.

The trend toward increased heat-load density shown in the previous figure is expected to continue as long as user demand grows. Customers' escalating insistence on services such as Voice over IP (VoIP), Video on Demand (VoD) and music downloads has nearly doubled the number of servers worldwide between 2000 and 2005. To meet these growing needs, information technologists have expanded the amount of equipment in their existing facilities or built additional, larger data centers. Unfortunately, both solutions create cooling nightmares. Simply adding more equipment can overload the heating, ventilation and air conditioning (HVAC) systems currently in place or cause premature aging that eventually leads to failure of electronics. Likewise, larger data centers can be more challenging to keep cool since larger volumes of air possess more turbulent airflows.

The negative effect of turbulent air is shown in Figure 2. In this figure, hot turbulent air (dark blue) disrupts cold air flow (light blue) at the top of the racks. This unintentional mixing of hot and cold air in the data center decreases the efficiency of the cooling process and drives up electricity costs.

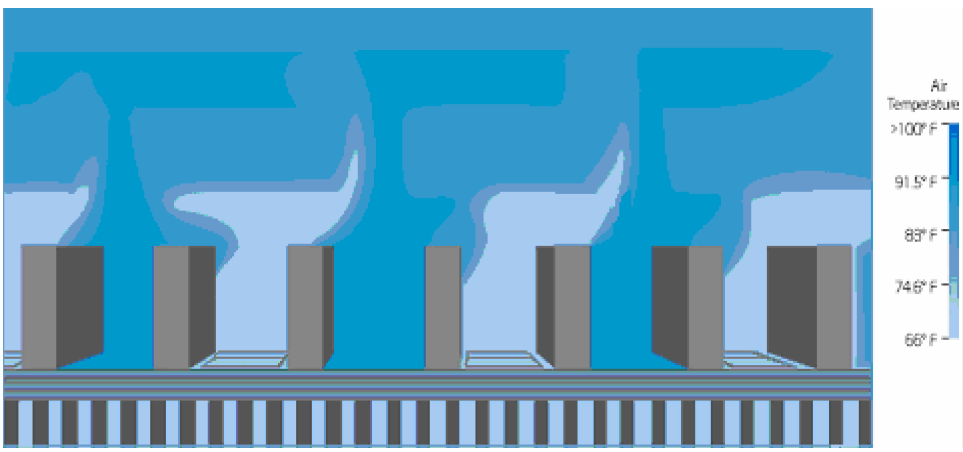

Figure 2: Data Center Air Flow[8]

Data Center Measurements

To absorb the rising heat load of data centers, more cooling capacity is required. Despite the use of proper HVAC, data centers are unlikely to have uniform temperature distribution. For efficient cooling, TIA 942 recommends that rows of racks should be aligned such that the fronts of equipment face the cold aisles. The exhaust of two rows of racks should face the hot aisles.

In order to gain an understanding of the typical operating conditions in functioning data centers, temperature testing was conducted in five different facilities. Temperature was measured at numerous locations throughout each data center including the ambient temperature of hot and cold aisles, equipment fan outlets, equipment air intakes and within cable bundles running both inside and outside of the cabinets. Temperatures as high as 37.9 °C (~100 °F) were found (as shown in Table 1).

Table 1: Temperature Measurements of Cabling in Data Centers

Data Center	Floor Space (Square feet)	Temperatures			
		Maximum °C (°F)	Minimum °C (°F)	Average °C (°F)	Maximum in Cable Bundles °C (°F)
A	Unknown	37.9 (100.3)	26.7 (80.0)	33.5 (92.3)	37.1 (98.8)
B	2800	35.1 (95.1)	19.8 (67.6)	23.6 (74.4)	22.8 (73.1)
C	6400	34.4 (93.9)	13.9 (57.1)	23.7 (74.7)	31.7 (89.1)
D	960	23.7 (74.7)	18.2 (64.7)	20.0 (68.0)	21.8 (71.3)
E	1000	22.1 (71.8)	14.9 (58.8)	19.0 (66.2)	19.0 (66.2)

The temperature of the cable bundles was measured on the jacket to avoid any interference with the normal operations of the data center. The increased temperatures found on some of the cable bundles in several of the data centers were caused either by the cables directly touching a piece of hot equipment or by hot air being expelled from the equipment directly onto the cables.

Recommendations

Imbalance between the thermal load and cooling capacity can raise the temperature in data centers up to 40°C. This temperature level can increase not only the insertion loss of the structured copper cabling but also can reduce the performance of other equipment[6] in data centers. In order to minimize the risk of performance degradation in the channels, Nexans has the following recommendations for planning, installation and operation of the data center physical plant:

Planning: Determining the present and future cooling capacity requirements and heat load distribution of the data center is fundamental. At present, there are several useful tools to simulate the thermal dynamics of the data centers before building them[9,10] There are also many general guidelines for data center design and layout that provide a good starting point[5,11,12,13]. For example, a raised floor with hot and cold aisles is recommended to improve the cooling process. Floor heights of at least 18 inches are generally needed to provide the correct volume of air required for the specified airflow. The CRAC (Computer Room Air Conditioning) unit should be placed to provide the shortest possible distance for the hot air to return to the unit. Also, ceiling returns for hot air are more efficient because they help minimize the amount of mixing between supply and exhaust air. Depending on the height of the racks or cabinets, it may be beneficial to supply cool air from both the ceiling and the floor. This helps to prevent the equipment at the top of the cabinets from pulling in hot exhaust air from the rear of the cabinets.

Installation: Elevated temperatures can result in elevated insertion loss, which may cause channels near the limit to have insufficient headroom for robust network operation. Recognizing the thermal issue and the possible resulting performance degradation, it is recommended to avoid installing the cabling plant in areas where heat is expected to accumulate. For example, minimize the amount of overhead cable bundles parallel to the hot aisles. The shorter the length of cable subjected to extreme temperature variations, the lower the increase in insertion loss. Additionally, bundles should be placed so that they do not unnecessarily hinder air flow.

Ideally, cables would be cooler if installed below the raised floor, however, data centers often reserve this space for power cabling and to allow future increases in the amount of air-flow, so this installation is not always possible.

In cases when cable is operating at 40°C or higher, the application may require cables with significant performance headroom.

Monitoring: Monitoring the temperatures at different times and locations in the data center is critical. The heat-load of the data center is not uniform. Nor is the amount of power dissipated by different equipment, which exhibits a wide range of variability. An understanding of these dynamics will optimize the use of resources for cooling. Being aware of the power load of the different types and models of equipment, and distributing them strategically throughout the data center can help to avoid extreme hot spots.

References

[1]Jonathan G. Koomey, "Estimating Total Power Consumption by servers in the U.S and the World", February 2007.

[2] URL: http://www.energystar.gov/.

[3] URL: http://www.thegreengrid.org/.

[4] "IBM Unveils Plan to Combat Data Center Energy Crisis, May 2007, (URL: http://www.hpcwire.com/hpc/1561201.html).

[5] "TIA/EIA 942 Telecommunications Infrastucture Standard for Data Centers," April 2005.

[6] Marianne Kolbasuk McGee, "Data Center Energy Consumption has doubled since 2000," February 2005

[7] URL: http://www.upsite.com/TUIpages/whitepapers/tuiheat1.0.html.

[8] D. Garday and D. Costello, "Air-Cooled High-Performance Data Centers: Case Studies and Best Methods", Intel Information Technology Computer Manufacturing Thermal Management, November 2006, (URL: http://www.intel.com/it/pdf/air-cooled-data-centers.pdf

[9] URL: http://www.inres.com/Products/TileFlow/tileflow.html

[10] URL: http://www.flomerics.com/products/flovent/

[11] "Optimizing data centers for high-density computing," HP Technology brief, Second Edition, 2005.

[12] David Moss, "Guidelines for Assessing Power and Cooling requirements in the Data Center," Dell Power Solutions, August 2005, (URL: http://www.dell.com/downloads/global/power/ps3q05-20050115-Moss.pdf).

[13] W. Tschudi, et al. "Measuring and Managing Data Center Energy Use", HPAC Engineering, March 2006, (URL:GreenBiz | Measuring and Managing Data-Center Energy Use)

Data Communications Competence Center

Nexans' Data Communications Competence Center, located at the Berk-Tek Headquarters in New Holland, Pennsylvania, focuses on advanced product design, applications and materials development for networking and data communication cabling solutions. The Advanced Design and Applications team uses state-of-the-art, proprietary testing and modeling tools to translate emerging network requirements into new cabling solutions. The Advanced Materials Development and Advanced Manufacturing Processes teams utilize sophisticated analytical capabilities that facilitate the design of superior materials and processes. The Standardization and Technology group analyzes leading edge and emerging technologies and coordinates data communication standardization efforts to continuously refine Nexans' Technology Roadmap. An international team of experts in the fields of cable, connectors, materials, networking, standards, communications and testing supports the competence center. The competence center laboratories are a part of an extensive global R&D network that includes eight competence centers, four application centers and two research centers dedicated to advanced technologies and materials research.