ABSTRACT

Given the explosive growth of data, scalability and fault tolerance have become a fundamental challenge for data center network structures. Temperature in data centers significantly affects the failure ratio of high-speed network devices. Various types of air distribution schemes influence the temperature of network equipment differently, and the cooling cost in data centers dominates the overall energy cost. On the basis of the energy efficiency of cooling systems, this study analyzes and compares the thermal load distribution in the enclosure of standard and non-standard data centers by considering the effects of the external environment. Analysis results demonstrate that the external environment significantly affects the thermal load of non-standard data centers. By leveraging on the air temperature outside data centers and on the inlet/outlet of IT equipment, the air temperature and return air temperature of air conditioning are calculated when performing hot and cold aisle containment. The calculations indicate that sealing an appropriate aisle (hot or cold aisle) can significantly reduce the energy consumption of cooling systems in terms of the external air temperature outside data centers. Furthermore, if the air temperature outside data centers is higher than the temperature at the inlet of IT equipment, sealing the cold aisle outperforms sealing the hot aisle. By contrast, the aisle to be sealed depends on the energy efficiency ratio of the air conditioning.

Keywords: Cold Aisle Containment, Cooling Efficiency, Data Center, Hot Aisle Containment

1. INTRODUCTION

The explosive growth of data from information digitization has been identified as the key driver the increasing requirements of data centers. A total of 161EB data were created and copied in 2006 (F. Ganz et al., 2007), and the amount of data increased to 1,800EB in 2011 (F. Ganz et al., 2008). The annual growth of data has reached 60%, and all data are distributed across

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global data centers. Over the past few years, many research efforts have been invested in designing highly scalable and fault-tolerant data center network structures because of the explosive growth of data (Al-Fares, Loukissas, & Vahdat, 2008; Costa, Donnelly, Shea, & Rowstron, 2010; Greenberg et al., 2009; Guo et al., 2008; Li et al., 2009; Mysore et al., 2009; Xie, Deng, & Zhou, 2013). The temperature in data centers significantly affects the failure ratio of high-speed network devices. Therefore, understanding the cooling efficiency of the thermal environment in data centers is important in implementing highly fault-tolerant data center network structures.

Energy efficiency has become one of the most important challenges in designing data centers. For example, in 2007, ICT used approximately 8% of the electricity generated worldwide, of which approximately 4% was consumed by data centers (Borzycki, 2011). Moreover, new data centers in the United States are projected to demand 5GW of power (which is approximately 10% of the current generating capacity of California) and cost $4 billion/year to power in 2005 (Chase & Doyle, 2001). One average data center in the United Kingdom consumes more power than the city of Leices- ter in a year. The energy cost of a single data center in the United Kingdom is approximately £7.4 million a year until 2010 (Fildes, 2006). Moreover, network power consumption is expected to occupy 20% of the total ICT power consumption in Japan by 2025 (Imai, Leibnitz, & Murata, 2013).

A large number of network equipment exist in data centers and emit abundant heat. Network equipment fails if the temperature is high. Moreover, ICT is a large energy consumer (Vizziello & Favalli, 2013) and the cooling cost in data centers dominates the overall energy cost. Cooling cost reportedly constitutes a large portion in the energy cost of data centers (The Green Grid, 2011; Lee & Zomaya, 2012). Cooling cost can reach up to 50% of the overall energy cost (Sawyer, 2004). Even with the advanced cooling technologies used in Blue Gene/L, cooling cost still remains to be a significant portion of the total energy cost (Li, 2012). Figure 1 shows the cost factors of a typical data center. The figure demonstrates that cooling cost would exceed server cost in data centers (The Green Grid, 2011). Furthermore, Gartner (The Green Grid, 2006) claimed that traditional data centers waste more than 60% of the energy used to cool equipment. Therefore, improving the efficiency of cooling systems in data centers is important.

Energy-saving techniques can be roughly categorized into five classes: (1) energy-saving techniques that exploit a natural cooling source, such as heat pipe air-conditioning technology, air-side energy-saving device, and water-side energy saver; (2) energy-saving techniques that exploit forms of air conditioning, such as air handling unit, direct liquid-cooled air conditioning, rack-mounted air conditioning, and high-heat-density air conditioning; (3) energy-saving air conditioning devices, such as efficient water chiller and energy efficient room air conditioning; (4) optimization of the design of airflow organization, such as “up-return down-supply,” “side-return down-supply,” “up-supply up-return,” and “up-supply side-return”; (5) smart control technology, such as the virtual operation technology of air-conditioning systems and humidity control technology.

Airflow organization is the most important issue for the energy consumption of data centers. If airflow organization is not projected well, overheating occurs in data centers and air conditioning becomes inefficient. The study of the airflow of air conditioning has made great advancements thus far. Schmidt et al. (2007) compared both the advantages and disadvantages of air supply in various types of scenarios by numerical simulation and experimental measurement. Sorell et al. (2006) analyzed the effect of ceiling height on the overall airflow of data centers. Van Gilder et al. (2005) demonstrated the factors of airflow uniformity of floor openings. Hannaford (2004) analyzed the methods for reducing cold air backflow and the energy dissipation caused by hot and cold air partial short circuit. Niemann et al. (2011) discussed the influence of airflow in hot and cold aisle...
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Ming-Jeng Yang, Chin-Lin Kuo and Yao-Ming Yeh (2013). Applications and Developments in Grid, Cloud, and High Performance Computing (pp. 122-137). www.igi-global.com/chapter/dynamic-rightsizing-quality-controlled-algorithms/69031?camid=4v1a