Chapter 12

Green Data Center

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ABSTRACT

The presence of computing in our society is enormous, and the trend continues. While organizations around the world rely more and more indispensably on their data centers to protect their fast growing data and information, the energy consumption of data center is becoming a key environmental, social, and political issue. Therefore, it is very important to minimize the energy usage by data centers. Green data centers refer to energy-aware data center design rationale of minimized carbon footprint. Virtualization has become a revolutionizing technology for systematic design and deployment of green data centers. This chapter presents a comprehensive study of green data centers. First, the concept and basic systems configuration of energy-efficient data centers are introduced. Then, an elaborate collection of greenness metrics are discussed for profiling the energy issues of green data centers. Next, the state-of-the-art energy-aware techniques are presented for the design and deployment of green data centers. Finally, the challenges and the future directions are pointed out.

INTRODUCTION

Data (or information) is undoubtedly an organization’s most valuable asset. Data centers are an essential part of enterprise computing today to protect this asset. Organizations have to deal with remarkable financial and regulatory consequences and there is no comprehensive business continuity plan if data centers are disrupted and the data (or information) becomes unavailable, even for only short period of time. On the other hand, maintaining data center up running 24 hours a day and 7 days a week means real term of costs. Therefore, reducing energy consumption in data center without sacrificing service level agreement (SLA) can save significant amount of operation expenditure (OPEX).

Data centers are at the heart of the global economy. The modern corporations run and live on data. Data center efficiency is a strategic issue. Building and operating these data centers consumes ever-larger portions of corporate IT budgets. According to the U.S. Department Energy, data center facilities use more than 100 times the energy than standard office buildings or around 25,000 households.

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A data center can be defined as a facility devoted to populating a large group of networked servers and associated power distribution, networking, and cooling equipment, and used to host applications that store, manage, and process digital data. Based on this definition, green data center can be defined as energy-efficient data center with a minimum CO$_2$ emission. Green data center refers to energy-aware designs, protocols and algorithms of ICT equipment and cooling infrastructures for data center. A modern state-of-the-art data center typically has three main elements: servers, data storage, and a local area network (LAN) (Al-Fares, Loukissas, & Vahdat, 2008; A. Greenberg, Lahiri, Maltz, Patel, & Sengupta, 2008).

As illustrated in Figure 1, a data center is typically composed of several components: (i) computer servers, (ii) network equipment, and (iii) storage devices. Servers, routers, switches and storage devices are installed in rows of racks to allow easy access to the front and rear parts of each rack. A standard rack is metal frame or enclosure which has 19 inches in width and 42 units (U) in height. One unit is equal to 1.75 inches and most servers’ size is 1U or 2U. A typical blade server or switch will fit in 1U. More sophisticated rack will have built-in KVM (keyboard-video-monitor), rack power distribution, etc.

Data centers also equipped with non-IT equipment: (i) environmental control units, (ii) power delivery system, and (iii) power backup facilities. Environmental control units such as computer room air-conditioning (CRAC) units are strategically positioned to provide cold air into the plenum, forcing the space under the racks and blowing cool air through perforated floor tiles. Then, the cold air is absorbed through the servers by the fans in the servers. The resulted warmed air from the servers is directed toward the ceiling and eventually makes its way back to the CRACK unit intake. Air handling unit (AHU), typically placed on the data center floor, is responsible for conditioning and distributing air throughout the data center. Typically, chilled water system installed locally is used by CRACs to cool the returned hot air.

Wattage per square meter in data center has been escalating as computer servers comprising data center grow ever more powerful, and are populated in ever higher density. Lowering the energy consumption of data centers is a challenging task and complex issue because computing applications and data are mounting so fast in pace that increasingly larger servers and storages are needed to process them fast enough within certain time period.

Figure 1. Typical physical layout of a data center
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