Green data center: how green can we perform?

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ABSTRACT

Global warming and the increase of toxic waste generated by electronic devices are some of the issues that are being currently addressed through the use of the so-called "green technologies". Although the solution to these important problems does not depend on a single individual, industry, government, or nation, there are contributions that can be made at each of the levels indicated to reduce global warming and toxic waste. In this paper the authors' addresses some of these issues within the context of green data centers and why it is necessary to stimulate the creation of such centers to help us save the environment and the global community at large. In this respect green data centers can be both environmentally and financially efficient by reducing energy consumption.

Keywords: Green technologies, toxic waste, global warming, energy consumption.

INTRODUCTION

Global warming is one of the most pressing issues that we confront in this new century. It is so, because if the warming trend continues, the consequences could be not only dramatic but disastrous. In fact, according to Population Institute eleven of the world's 12 highest annual global temperatures on record have occurred since 1995 (Population Institute, 2007). The problem seems to be the direct result of an increasing world population along with its continuous demand for more fossil-based fuels (Population Institute, 2007). The latter has contributed to an increase in the concentration of greenhouse gases – carbon dioxide, methane, nitrous oxide, and fluorocarbons – which are the main culprits for the increasing earth temperature. Global warming can result in the melting of the polar caps (Gore, 2006). Although this may seem as an isolated issue, the melting of the polar cap will bring about the rising of the sea level and changes in the wind pattern around the earth. This, in turn, will cause severe floods and, paradoxically, long-term droughts on a global scale which have the potential of disrupting both life and the world's economy (Gore, 2006). As a result of the 1997 Kyoto Protocol for the United Nations Framework Convention on Climate Changes, most of the countries of the world began to take steps in reducing the emissions of greenhouse gases. These emissions are mainly the result of power plants that use fossil fuels to generate electricity. According to the EPA, power plants are responsible for 40 percent of the U.S.'s carbon dioxide emissions. In a global scale, the United States is among the top ten countries with most emissions of greenhouse gases (Greenhouse Gas Emissions by Country). However, the new emerging powerhouse economies of China, India, and the conglomeration of countries of the European Union are also contributing to the concentration of greenhouse gases at an accelerated pace (Schelling, 1992).

GREEN DATA CENTERS

One of the main objectives of "green technologies" is to reduce the "carbon footprint" required or generated by the computer technology (Mata-Toledo & Young, 2010). As we indicated earlier, power plants are highly responsible for the production of greenhouse gases. This is why it is necessary to reduce the demand of electricity required throughout the world, in particular, that required by computing data centers. According to EPA, U.S. data centers alone consume as much power in a year as is generated by five power plants (U.S. Environmental Protection Agency, 2007). Thus, for any data center to be energy efficiency is a must. A green data center (GDC) is similar to any other data center used as a repository for the storage, management and distribution of data. However, what makes a data center "green" is that the mechanical, electrical and computer systems are designed simultaneously to achieve maximum energy efficiency and minimum environmental impact (Gowri, 2005).

CONVERSION TO A GREEN DATA CENTER

The construction of a GDC is a large investment. Several steps need to be taken when a government or business entity considers the conversion of an existing data center to a GDC. The first and the foremost step is the evaluation of your data center in terms of energy efficiency. This step includes monitoring and measuring the consumption of energy for the entire enterprise (Corrigan, 2009). This initial step of monitoring the energy consumption allow the enterprise to estimate where energy consumption can be reduced and what equipment or hardware needs

replacement. This activity obviously helps in the consideration to redesign or start a new data center.

There are metrics that can help in analyzing the "greenness" of an existing data center. Two of the most popular metrics that can measure the "greenness" of an existing data center are Power Usage Effectiveness (PUE) and Data Center Efficiency (DCE) (TGR, 2009). These metrics are calculated based on the following equations:

$$\text{PUE (power use effectiveness)} = \frac{\text{Total power used by the data center building}}{\text{Power used of IT equipment}}$$

$$\text{DCIE (data center infrastructure efficiency)} = \frac{1}{\text{PUE}}$$

As an aid to the analysis of an existing data center, there are tools such as The Green Report created by RACKWISE^{TM} which calculates the PUE and DCIE from an organization's model of the data center. The report produced by this tool also breaks down resources consumption by type such as servers, network, storage equipment, or other. The Green Report is an excellent tool as it can provide the organizations with measures that can help the existing data center to become a GDC. A snapshot of the tool is shown below in Figure 1.

An average data center has a PUE of approximately 2 or roughly an equivalent of DCIE of 50%. This means that a data center will spend as much in cooling the equipment as it does in running the equipment (Garbin & Chang, 2009). These numbers may change with work load and outside temperatures. That the work load may change with the outside temperature may result in a vicious circle of energy consumption. In fact, consider that an increase in the outside temperature occurs. This increase will affect the temperature inside the data center which will require more energy to cool the equipment. This increase in the use of energy to cool the system will have an effect in the outside temperature. Fortunately, these increases are not too noticeable immediately but they add up over time.

Estimating the energy consumption of a data center can help us to determine the enterprise baseline energy. Based on this measurement, corrective measures can be taken to transition to a GDC. Without measuring the current consumption and setting target goals it is impossible to determine if the enterprise is benefitting from the green measures (Corrigan, 2009). This is the reason energy consumption should be monitored after green measures have been put in place as it affects all areas of an enterprise.

Some additional considerations that deserve our best attention are presented next. They will help in maximizing the efficiency of a data center and at the same time convert it to an environment-friendly center. One of the first and most vital aspect to consider is the evaluation of the current cooling system, and, if necessary, to redesign it or replace it altogether. Cooling systems are often overlooked in this transition process. A cooling system needs to be redesigned or replaced whenever it is not being used to its maximum capacity and/or it is using more energy than what was originally required (Garbin & Chang, 2009). Another aspect of the cooling system that needs consideration is the unnecessary redundancy that may be present due to the dual nature of the system as a cooling and heating system (Hengst, 2009). A basic rule of thumb for this type of system is to have a backup system that guarantees the functioning of the system 24/7. It is interesting to observe that, although most businesses have the acumen of projecting their future needs in terms of a cooling/heating system, they often neglect to evaluate their current one

and how it is performing (Pollack, 2008). In terms of energy consumption, it is important to concentrate on the current needs and not create unnecessary backup systems.

In the area of IT, and related to cooling and heating system, an important aspect to consider in the transition-to-green process is that of using adjustable equipment. Among this type of equipment, it is necessary to consider scalable blade servers (Behle et al., 2008). Servers of this type have a great computing power while occupying a small area and taking less time to cool. In addition to scalable it is recommended that modular systems be used based if necessary. Still within the IT area other suggestions to upgrade to a GDC are the use of energy-efficient servers and the use of high-efficiency power supplies (Mitchell, 2007). During and after the conversion process, it is highly recommended that all computing equipment meet or exceed the EPA current standards as well as being Energy star-rated (Hengst, 2009).

A critical analysis that also needs to be undertaken during the conversion process is that of monitoring the number of under-used servers (Hengst, 2009). For example, the enterprise may have servers that, due to the nature of the data stored in them, are used occasionally. Problems like this can be solved through storage virtualization software or hardware which can help in managing the use of these servers (Hengst, 2009). For example, a hardware device or a software application can be used to keep track of which server is being under-used. Once this is detected some of the running applications can be remapped to these under-used servers. This can make the applications location independent and thus application redundancy can be reduced.

To further benefit from the transition to a GDC, the enterprise should research on alternative sources of energy such as photovoltaic cells, wind energy, heat pumps, evaporative cooling and more. For example, a part of energy consumed by the enterprise can be created using the wind energy. Obviously, no transition will be successful if a manager is not only aware but also actively engaged in evaluating these alternative sources of energy and how they can fit within the enterprise (Hengst, 2009). In other words, once the "green question" becomes a part of the enterprise it will be always taken into account when the growth of the data center is an issue. It is also important to emphasize that unless the data center is converted there is no possible way to know the quantitative improvement in the consumption of energy. Clearly, it is assumed that the investment is huge and, in consequence, there is very less room for supposition and speculation. At any step of the transition process it is imperative that we be sure of what changes need to be done and how it will affect the transition process.

To guide the transition process, GreenCloud architecture has been proposed to address some of the issues mentioned before. The architecture focuses on online-monitoring, live virtual machine migration and Virtual Machine placement optimization (Liang et al., 2009). This architecture dynamically makes decision on migrating virtual machines among servers in order to fulfill the workload requirement and also save energy. Thus it addresses the issue of user performance by guarantying real-time performance while saving energy.

FIELDS CURRENTLY USING GREEN DATA CENTER

The educational institution sector is one of the largest consumers of energy (Dietrich & Schmidt, 2007). It needs to focus on reducing energy demands and thus improve the environment impact. In the process they need to help the students and community by making them aware of the earth-friendly practices that can be practiced at home and in offices. The educational institution itself can create a green data center by using the following practices, the "4 R's" identified by (Dietrich & Schmidt, 2007; Dietrich, Schmidt, Hogan & Allen, 2008):

- Regaining power and cooling capacity - As the energy costs are increasing, there is more emphasis on the power and cooling infrastructure. The power scheme being used currently in the enterprise will change with the increase and decrease in usage of energy. We need to regain the best possible balance for power and cooling capacity as the energy demands of the institution change.
- Recapturing resiliency – The increase in energy costs can lead to operating resiliency, thus raising the issue of reliability and performance. We need to use measures that do not affect the performance uptime and, at the same time, help to save energy.
- Reducing energy costs – Apart from the benefit of reducing the operating costs by reducing energy costs, the companies are being offered incentives from local utilities and state energy funds for using practices that reduce consumption of energy. According to a survey, fewer than half the computer users take advantage of the power management settings on their workstation when they are left on (Pereira, 2008).
- Recycling end-of-life equipment – Recycling has both financial and environmental benefits. A somewhat slow Fax or a printer machine may not fit into a busy IT office environment but can work for a Non-profit organization office.

The other largest consumer of energy is the industry sector. Various companies such as IBM™ and Dell™ have taken initiatives to create a GDC and are also trying to follow the earth-friendly practices. IBM has taken some measures to cut the energy consumption and in the process it has launched a project known as "Big Green Innovations". The skills of the business consultants in energy and utilities industry can be combined with the power of its supercomputers (LaMonica, 2007). Experts can devise models to measure the usage of energy in the supply chain of a company and use the supercomputers to figure out alternate methods to save the consumption of energy and how to restructure the company's network. IBM™ launched the standard-size building blocks that use a modular design that cuts the energy consumption of the center into half as compared to the other data centers (LaMonica, 2008). As stated by the vice president of global site and facilities at IBM™ in June 2008, "In the past year, IBM™ has been able to reduce energy consumption up to 50 percent as part of 2,000 consulting engagements" (LaMonica, 2008). This shows the commitment of this industry in helping the business as well as the environment."

Dell™ has also taken several initiatives to go "green". Some of the examples are: The Green Grid, the Climate Savers Computing Initiative and 80Plus. The Green Grid plan helps in improving the data center energy efficiency, the Climate Savers plan focuses on power consumption characteristics and power management features of individual IT components and the 80Plus plan is an electric-utility incentive program that also helps in improving the computer power supplies efficiency (Pflueger, 2008). There are other companies that have launched similar projects like GE™ and Oracle™'s Project Sequoia (Kanellos, 2006). There are various other industries that have taken initiatives to go "green" (Wheeland, 2008).

CONCLUSION

The primary concern before and after converting to a green data center should be power management. Most of the administrators are not comfortable monitoring power usage because the main concern is performance. The administrators are more concerned about performance uptime and not the power usage. This practice needs to change and power usage should be measured and monitored where needed. Even after converting to a GDC, the enterprise needs to

monitor the usage to reap the benefits of the transition-to-green process. The vendors can also help in power management by selling energy efficient hardware or recyclable hardware. Based on the growth of the industry, the power needs are increasing and thus there is a need to monitor the power usage. As the power needs increase, more earth-friendly measures can to be taken to help the environment. Also, the management and administrators need to discuss the increasing needs of the data centers. The power scheme currently used in a data center will change with the growth of industrial as well as the educational sector.

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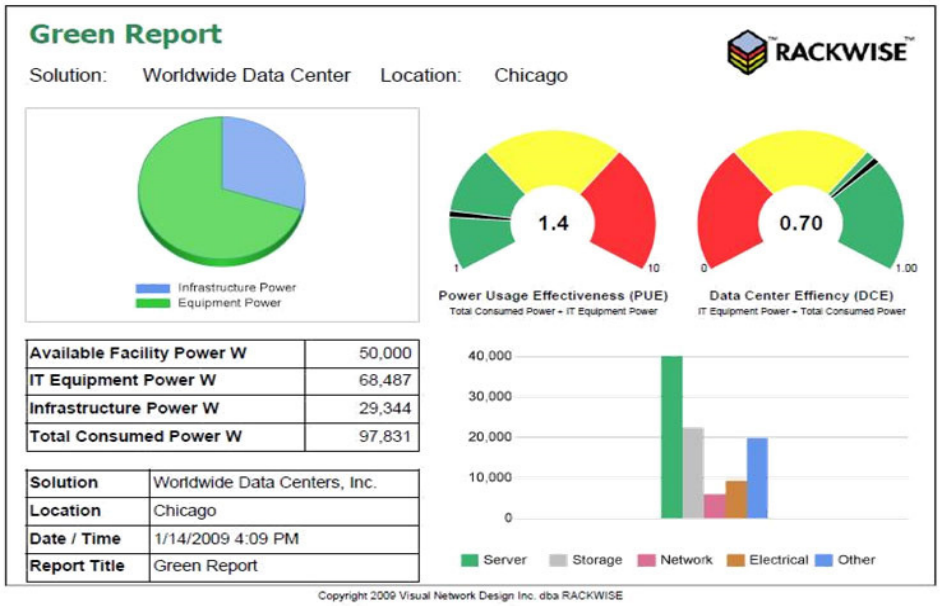

Figure.1.The Green Report Tool [TGR (2009)]