ENERGY EFFICIENCY AND ENVIRONMENTAL CONSIDERATIONS FOR GREEN DATA CENTERS

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ABSTRACT

The advancement of business and social practices based on information and communication technologies (ICTs) in the last few decades has transformed many, if not most, economies into e-economies and businesses into e-businesses. For economies, ICTs are increasingly playing a critical role in transforming and generating economic opportunities. Technology has a potential to create sustainable business and society both in grim and green economic times. Especially, the recovery from the current economic crisis is going to lead to more greener and energy efficient industries. Data centers are found to be major culprits in consuming too much energy and generating higher level of CO_2 in their overall operations. In order to handle the sheer magnitude of today s data, servers have become larger, denser, hotter, and significantly more costly to operate using more power than being used earlier. This paper determines the properties and attributes of green IT infrastructures and the way they will be helpful in achieving green sustainable businesses. The proposed attributes and characteristics of green IT using Virtualization technology are very productive and efficient for data centers in making them more energy efficient and green, hence reducing the emission of greenhouse gases so that their overall effect on global warming can be reduced or even eliminated. The proposed attributes indicate the qualities of green IT to enhance the proper utilization of hardware and software resources available in the data center.

Keywords: *Energy Efficiency, Green IT Attributes, Green IT, Environmental Sustainability*

1. INTRODUCTION

Seldom does a day pass in which we do not hear or read about sustainability or going green. Environmental concerns are constantly in news headlines, and the impact of technology on our environment is significant. Large technology organizations such as, Dell, HP, IBM, Sun, Hitachi, and Fujitsu have introduced green and sustainable initiatives. Green is generally understood to mean Friendly to the environment and energy efficient. Sustainable implies planning and investing in a technology infrastructure that serves the needs of today as well as the needs of tomorrow while conserving resources and saving money. Organizations are quite concerned with environmental issues, but they have also come to realize that sustainable business practices can significantly enhance the bottom line.

Data centers have become an increasingly important part of most business operations in the twenty-first century. With escalating demands and rising energy prices, it is essential for the owners and operators of these critical facilities to assess and improve their performance. In contexts ranging from large-scale data centers to mobile devices, energy use is an important concern. In data centers, power consumption in the U.S has doubled between 2000 and 2006, and will double again in the next five years [1]. Server power consumption not only directly affects a data center s energy costs, but also necessitates the purchase and operation of cooling equipment, which can consume one-half to one Watt for every Watt of power consumed by the computing equipment [2]. As new servers are being added continuously into data centers without considering the proper utilization of already installed servers, it will cause an unwanted and unavoidable increase in the energy consumption, as well as increase in physical infrastructure, like over-sizing of heating and cooling equipments. This increased consumption of energy causes an increase in the production of greenhouse gases that are hazardous for the environment. Hence it not only consumes space and energy, but also costs environmental stewardship [3]. The continued growth of data center power consumption impacts everything from business enterprises, and power supply companies to the environment. With more efficient energy use in data centers, power supply companies will face less demand and the possibility of excess power, which could help limit blackouts, reduce carbon dioxide emission and cut other greenhouse gases. In addition, energy use has implications for reliability, density, and scalability. As data centers house more servers and consume more energy, removing heat from the data centers becomes increasingly difficult [4]. Since the reliability of servers and disks decreases at high temperatures, the power consumption of servers and other components limits the achievable density of data centers, which in turn limits their scalability. Furthermore, energy use in data centers is starting to prompt environmental concerns of pollution and excessive load placed on local utilities [5]. These concerns are sufficiently severe for the large companies that are starting to build data centers near electric plants in cold weather environments [6]. For

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the business enterprise, an increase in data center efficiency can save significant energy costs. However, even with the global presence of many companies, these metrics are often not applied consistently at a global level. All of these factors are increasing the public s awareness and global concerns of these current power consumption trends.

The world is in the biggest data centre construction boom in history. The U.S. is spending $16 billion a year building additional data centers, with another $6 billion on refurbishing existing ones. Experts say that $3 billion a year should be spent to build new electrical power plants to meet the supply needs of these data centers except it is not being spent thus [7]. The Smart 2020 report published by the Climate Group and GeSI revealed that in 2002, the global data centre footprint, including equipment use and embodied carbon, was 76 million metric tons of carbon dioxide ($MtCO_2e$) and this is expected to increase more than three times by 2020 to 259 $MtCO_2e$, making it the fastest-growing contributor to the ICT sector s carbon footprint, at 7 per cent per annum in relative terms. If growth continues in line with the demand, the world will be using 122 million servers in 2020, up from 18 million today [8]. With energy prices increasing worldwide, the operational costs of data centers continues to increase steadily. Besides the cost, availability of electrical power is becoming a critical issue for many companies whose data centers have expanded steadily.

Enterprises, governments, and societies at large have a new important agenda: tackling environmental issues and adopting environmentally sound practices. Over the years, the use of IT has exploded in several areas, improving our lives and work, and is offering convenience along with several other benefits. We are passionate about advances in and widespread adoption of IT. However, IT has been contributing to environmental problems, which most people do not realize. Computers and other IT infrastructure consume significant amounts of electricity, placing a heavy burden on electric grids and contributing to greenhouse gas emissions. Additionally, IT hardware poses severe environmental problems both during its production and its disposal. IT is a significant and growing part of the environmental problems of today s world. There is a need to minimize or eliminate, where possible, the environmental impacts of IT to help create a more sustainable environment. To reduce environmental problems related to IT and to create a sustainable environment, the IT sector and individual computer users should green their IT systems, as well as the way they use these systems [9].

Legally, ethically, and socially speaking, it is required to green our IT products, applications, services, and practices. Green IT benefits the environment by improving energy efficiency, lowering greenhouse gas emissions, using less harmful materials, and encouraging reuse and recycling. Factors such as environmental legislation, the rising cost of waste disposal, corporate images, and public perception give further impetus to the green IT initiatives. Green IT is a hot topic today and will continue to be an important issue for several years to come. To foster green IT, one should understand: What are the key environmental impacts arising from IT? What are the major environmental IT issues that need to be addressed? How can we make our IT infrastructure, products, services, operations, applications, and practices environmentally sound? What are the regulations or standards with which we need to comply? How can IT assist businesses and society at large in their efforts to improve environmental sustainability? This paper highlights some of these issues, and then presents a holistic approach to greening IT in e-businesses, especially data center industry. A green IT strategy for data centers is proposed and specific ways to minimize IT s environmental impact have been outlined.

2. ENVIRONMENTAL IMPACT OF INFORMATION TECHNOLOGY

For over 25 years, researchers have been cognizant of the potential for the rise in trade to negatively impact the environment. There is a global change in the world s climate due to intensifying emissions of greenhouse gases and other fuel combustions, causing potentially disastrous consequences, and as these problems become global, a new spotlight appears on IT. IT is turning out to be both a solution and problem for environmental sustainability. Unfortunately, it is contributing enormously towards environmental problems causing gigantic problem of global warming. Its immense use has exploded in almost all areas of business activities offering great benefits and convenience and at the same time transforming businesses and societies into a global village [10]. IT affects our environment in several different ways. Each stage of a computer s life from production, use to disposal presents environmental challenges. Manufacturing computers and their various electronic and non-electronic components consume electricity, raw materials, chemicals, water, and generate hazardous waste. The increased

number of computers in use and their frequent replacement make the environmental impact of IT a major concern. This increase in energy consumption results in increased emission of greenhouse gases as most of the electricity is generated by burning coal, oil, or gas. All these factors contribute towards environmental problems. As businesses balance their growth and production with environmental risks, they are baptized to innovate and implement greener solutions to make IT systems and work practices energy efficient and environment friendly [11].

Data center operational managers need to implement green IT techniques and policies to reduce greenhouse gas emissions by improving energy efficiency, thereby reducing the rate of energy consumption by improving the utilization of already installed equipments [12]. Other policies, like the use of lower emission, clean fuels, such as wind, solar, biomass, or hydroelectric, would reduce total emissions by reducing emission intensity, while maintaining the rate of energy consumption [13]. Today global warming is a much-debated issue amongst the scientific society. The consensus among most of the scientific community is that the problem of global warming is largely due to an increase in greenhouse gases in the atmosphere as a result of human activities [14]. Energy savings play a key role in reducing the overall cost of ownership of data center, and is being discussed everywhere for doing businesses with due consideration towards sustainable development WITH ITS economic, social and environmental dimensions. One of the ways, organizations can reduce their carbon footprints and lessen their harmful environmental impact is through adopting environmental friendly Information Technology (IT) practices, frequently referred to as green IT [15].

These practices mitigate environmental risks associated with the emergence of a green economy. Organizations that mitigate these risks more effectively than their competitors would be able to gain a competitive advantage. Global warming is a matter of high concern for all inhabitants living on this planet. Individuals, organizations and governments are doing their best to control the warming and make this tiny planet a livable place. Information Technology and telecom/data networks can play an equally important role along side other direct means for solving this menace. Many technologies are in place and others are to be developed or fine tuned to make them ready for use in reducing the emission of greenhouse gases into atmosphere [16]. It has taken more than 30 years for data center industry to evolve to a point of modularity that is conducive to alignment of efficiencies in use and design across disparate infrastructures. The green movement has been around for many years to evolve to a point where the economics of sustainable practices are well understood. Traditionally, environmentalism has been perceived to be at odds with economic prosperity. Environmental stewardship encompasses the notion of balancing current resource consumption with the resource requirements of future generations. The landmark Brundtland report defines sustainable development as meeting the needs of the present without compromising the ability of future generations to meet their own needs [17].

The use of green IT extends to many areas and activities, including power management; data center design, layout, and location; the use of biodegradable materials; regulatory compliance; green metrics and green labeling; carbon footprint assessment tools and methodologies; and environment related risk mitigation. A growing number of IT vendors and users have begun to turn their attention towards green IT triggered by the imminent introduction of more green taxes and regulations; there will be a major increase in demand for green IT products and solutions. Green IT is becoming a hot topic these days and for years to come, as it becomes imperative to develop environmentally sustainable IT, from both economic and environmental viewpoints [18].

3. CHALLENGES FACED BY DATA CENTERS

There is no single factor that can be blamed for IT inefficiency. Worse, inefficiency seems to grow incrementally over time as environment becomes older and more complex. Each new application being added seems to require another server, which requires administrative time to keep running, while it also consumes power, space, and expensive network ports in data centers. The data center industry has a number of related problems such as:

3.1 Inconsistent Measuring Metrics and Benchmarking

It is highly important for data center managers to measure the performance of their data centers regularly so that efficiency measures should be taken to make data centers energy efficient and green. But unfortunately there is no industry standard metric available acceptable worldwide to measure the performance in terms of energy efficiency and CO_2 emissions. Data center managers are currently

equally split between using external benchmarks, home grown tools, financial analysis, and commercial asset/financial management tools, with no clear leader and metric. It is evident from different discussions that measuring IT performance is difficult.

3.2 Large Number of Underutilized Servers

Servers are the major components responsible for performing most of the processing being performed in data centers. There number is continuously increasing as the demands from businesses grow. Due to their increased number, they are the leading consumer of IT power in any data center. Data centers are plagued with thousands of servers mostly underutilized having utilization ratio of only 5 to 10% consuming huge amount of energy and generating a lot of greenhouse gases [3].

3.3 Power Efficiency of IT Equipment

Data center comprises many types of equipment like servers, UPS, PDU s, Chillers, Cracks, etc. All of these components consume enormous amount of power to provide services to end users. Most of the data managers think that IT equipments are significant source of electrical waste. Proper efficiency measures can reduce these consumptions and help data center managers implement environment friendly and green data centers.

3.4 Establishing Performance Requirements and Maximizing IT Operations

Effective application service delivery requires a continuous understanding of end-to-end application performance requirements. In a data center environment, with rapidly changing dynamic workload and resource allocation, continuous measurement to establish performance requirements is especially vital. This understanding should start when the applications are still in development, so that IT can avoid any surprise performance problems during and immediately after production deployment. As application usage changes, continuous measurement is required to adapt workload and resource allocation and maintain desired service levels. When application changes are made, or new features are added, performance requirements will need to be re-established to again avoid potential disruption.

3.5 Environmental Issues and Problems

The growing accumulation of greenhouse gases is changing the world s climate and weather patterns, creating droughts in some countries and floods in others. It is slowly pushing global temperatures higher, posing serious environmental problems to the world. For instance, 2005 was the warmest year on record, and the 10 warmest years have all occurred since 1980. Global data shows that storms, droughts, and other weather-related disasters are growing more severe and frequent. To stop the accumulation of greenhouse gases in the atmosphere, the growth of global emissions should be watched. Electricity is a major cause of climate change, because the coal or oil that helps generate electricity also releases carbon dioxide, pollutants, and sulphur into the atmosphere. These emissions can cause respiratory diseases, smog, acid rain, and global climate change. Reducing electric power consumption is the key to reducing carbon dioxide emissions and their impact on environment and global warming. With this in mind, IT professionals, members of the IT industry, and IT users should focus on individually and collectively creating a sustainable environment. In the following sections, environmental impact and proposed green IT measures are given.

4. PROPOSED WORK AND ENERGY EFFICIENCY ATTRIBUTES FOR GREENING DATA CENTERS

The continued rise of Internet and Web applications is driving the rapid growth of data centers. Enterprises are installing more servers or expanding their capacity. The number of server computers in data centers has increased six fold to 30 million in the last decade, and each server draws far more electricity than earlier models. Aggregate electricity use for servers doubled between 2000 and 2005, most of which came from businesses installing large numbers of new servers. [19]. One problem with the greening of IT is that it forces organizations to buy more. Plans usually call for things like more energy efficient servers, intelligent sensors for data center cooling, server virtualization software, low power monitors and devices that turn off dormant computers [20]. The social, financial, and practical constraints involved will force businesses and IT departments to reduce energy consumption by data centers. Efficiency of the data centers can be improved by using new energy-efficient equipment, improving airflow management to reduce cooling requirements, investing in energy management software, and adopting environmental-friendly designs for data centers and new measures to curb data centers energy consumption.

The proposed energy efficient green IT attributes help to achieve energy consumptions, underutilization, emission of greenhouse gases, environmental concerns, global warming issues and intensive administrative labor that contribute towards data center inefficiency. The proposed attributes highlight top IT improvements in data center spanned across data center energy efficiency, infrastructure consolidation, reduced administrative labor, better IT process, improved service time, and reduced greenhouse gases, to reduce the effects of global warming on environment. These benefits may vary significantly across businesses of different types. In particular, companies with less than $1 billion in revenue said that they benefited more from physical consolidation of IT assets, whereas companies with $5 billion or more in revenue benefited the most from improving the energy efficiency of their data centers. These attributes are:

- Baseline Environment;
- Virtualize Servers;
- Consolidate IT;
- Improve Data Center Efficiency;
- Update IT Processes.

4.1 Baseline Values

The first step in greening of the data centers is to baseline all the requirements to get the maximum value out of data center greening programme. Now more than ever, energy efficiency seems to be on everyone s minds. Faced with concerns such as global warming and skyrocketing energy costs, more and more companies are considering if and how to increase efficiency. E-businesses that rely on data centers must make hard decisions to accommodate growing demands without creating a negative impact on their finances or the environment. The data center baseline study report must be based on in-depth interviews with engineers and data center managers. These professionals represent a cross-section of companies in terms of industry type, size, number of servers being used, storage capacity, age, geography, etc.

The baseline study provides measures to boost efficiency, as well as the incentives for making changes to make data center energy efficient. The growth in IT demand is among the most common obstacles in becoming more energy efficient. Data centers must contend with constant expansion in data volume, along with new and extended application requirements. The study also gets awareness about how to calculate the power load of individual IT devices. The data center baseline report also outlines helpful strategies for approaching energy efficiency in the data centers. The discussion covers virtualization, airflow management, server decommissioning, equipment upgrades, storage consolidation and optimization, and use of fresh-air cooling and renewable energy sources. The report also includes tips on how to improve energy efficiency in the data center so that other data center professionals can evaluate their options and identify the most appropriate steps for their particular organizations.

The process of creating the baseline of a data center starts by creating an inventory of all resources including servers, resources they require, available resources and their associated workloads, this process is called discovery process. The inventory process includes both utilized and idle servers. It also includes information related to [21]:

- Make and Model of the Processor;
- Types of processors (socket, Core, Threads, Cache);
- Memory size and speed;
- Network type (Number of ports, speed of each port);
- Local storage (number of disk drives, capacity, RAID);
- Operating system and their patch levels (service levels);
- Applications installed;
- Running services.

4.1.1 Inventory Process

It is very important for an organization to know in advance the total content of its infrastructure before implementing green IT techniques. This is the most important step in Green IT projects. There are many tools available from different vendors for performing initial analysis of an organization. Microsoft Baseline Security Analyzer (MBSA) tool provides different information like IP addressing, Operating System, installed applications and most importantly vulnerabilities of every scanned system. After analyzing, all generated values are linked to MS Visio, which generates a complete inventory diagram of all components and also provides details about each component being analyzed [22]. Microsoft Assessment and Planning toolkit (MAP) is another tool for the assessment of network resources. It works with Windows Management Instrumentation (WMI), remote registry service or with simple network

management protocol to identify systems on network [23]. VMware, the founder of X-86 virtualization, also offers different tools for the assessment of servers that could be transformed into virtual machines. VMware Guided Consolidation (VGC) is a powerful tool that assesses network with fewer than 100 physical servers. Since VGC is an agent-less tool, it does not add any overhead over production server s workload [24].

4.1.2 Categorize Server Resources

After creating server inventory information, the next step is to categorize the servers and their associated resources and workloads into resource pools. This process is performed to avoid any technical political, security, privacy and regulatory concern between servers, which prevent them from sharing resources. Once analysis is performed, each server role can be categorized into groups. Server roles are categorized into following service types:

- Network infrastructure servers;
- Identity Management servers;
- Terminal servers;
- File and print servers;
- Application servers;
- Dedicated web servers;
- Collaboration servers;
- Web servers;
- Database servers.

Aggregate utilization data helps initially to target particular servers and storage devices as candidates for consolidation. But it does not tell the whole story, since many servers are busy for short periods of time on a periodic basis. In that case system management tools should be used to collect trends for the entire cycle of systems with applications that run on a weekly, monthly, or quarterly basis. Some capacity or consolidation planning tools can simplify this task by superimposing historic data for multiple systems to simplify analysis. To optimize the consolidation scenarios, consider using performance modeling and consolidation planning tools to analyze different consolidation and virtualization scenarios. Different consolidation strategies can be followed to consolidate different components of data center depending on the workloads and nature of consolidation. Modern planning tools take mathematical approach to optimizing capacity while minimizing configuration conflicts between dissimilar systems or those that will compete for resources at the same time.

4.2 Virtualization Process

Virtualization promises to dramatically change how data centers operate by breaking the bond between physical servers and the resource shares granted to customers. Virtualization can be used to slice a single physical host into one or more virtual machines (VMs) that share its resources. This can be useful in a hosting environment where customers or applications do not need the full power of a single server. In such a case, virtualization provides an easy way to isolate and partition server resources. The abstraction layer between the VM and its physical host also allows for greater control over resource management. The CPU and memory allocated to a virtual machine can be dynamically adjusted and live migration techniques allow VMs to be transparently moved between physical hosts without impacting any running applications.

Server virtualization has become popular in data centers since it provides an easy mechanism to cleanly partition physical resources, allowing multiple applications to run in isolation on a single server. It categorizes volume servers into different resource pools depending on the workload they carry and then server consolidation is applied. This technique decouples software s from hardware and splits multi processor servers into more independent virtual hosts for better utilization of the hardware resources, allowing services to be distributed one per processor. In server consolidation many small physical servers are replaced by one large physical server to increase the utilization of expensive hardware resources, reducing the consumption of energy and emission of CO_2 [3]. Server virtualization complements overall IT consolidation projects by allowing firms to share capacity across multiple underutilized systems and shrink the hardware footprint of applications that cannot be completely eliminated. Data center managers focus on reducing hardware and operational costs with virtual servers, yet overlook significant improvements they should make to disaster recovery and time lapses to market for applications. By offering improved service levels for virtualized servers, internal customers migration to virtual infrastructure can be accelerated, while improving overall satisfaction with IT services.

4.2.1 Physical to Virtual Live Migration

This is the most critical, time-consuming and painful operation when performed manually, since it includes cloning the existing operating system and restoring it

on an identical machine, but at the same time changing the whole underlying hardware, which can lead to driver reinstallation or possibly the dreadful blue screen of death. To avoid these ambiguities, virtualization vendors started to offer different physical to virtual (P2V) migration utilities. This utility software speeds up the movement of operation and solves on the fly driver incompatibilities, by removing physical hardware dependencies from server operating systems and allowing them to be moved and recovered. Instead of having to perform scheduled hardware maintenance at some obscure hour over the weekend, server administrators can now live migrate a VM to another physical resource and perform physical server hardware maintenance in the middle of the business day. Virtuozzo for Windows 3.5.1 SWsoft itself introduced a physical to virtual (P2V) migration tool called VZP2V. This tool can remotely install P2V knowing machine administrative username and password.

4.2.2 Management to Increase Utilization Ratio

Server consolidation increases the utilization ratio of underutilized volume servers from 10% to 50% or even more by proper management of workloads to be virtualized to increase the productivity of data center and reduces the total cost of ownership. There is always a room for improvement, however, as many data centers leave a substantial amount of headroom on their virtual server hosts. Today, some data centers are consolidating the load of 5 to 10 virtual machines (VMs) on single server, while more experienced organizations are putting 25 to 30 VMs on a single server. Many administrators are reluctant to run servers at maximum capacity because they are concerned about the possibility of performance problems that could affect multiple applications simultaneously. In order to get to higher levels of hardware utilization, it is important to improve the administrator s visibility into the performance and availability of the virtual infrastructure with management tools designed for virtual servers. Active power management software can be used to help power your server infrastructure up and down depending on the demand for applications. This is particularly useful in virtual environments where live migration is used to consolidate VMs onto as few physical servers as necessary to maintain service levels, shutting down the rest.

4.3 Consolidate IT Resources

The best way to reduce the costs of hardware, software, labor, and facilities is to unplug unneeded infrastructures. But it is a complex task that requires a lot of legwork and detailed information on your assets to do it right. One needs to assess data center from all aspects and then categorize it into measurable units so that, consolidation can be applied and then benchmarking can be set properly to reduce the consumption of energy and emission of greenhouse gases. IT consolidation involves the consolidation of servers, storage devices, applications running, and operating systems. Virtualization increases the capability of the already installed equipments by increasing their utilization ratio and thus reduces the overall operational costs. Many data center managers tend to measure the consolidation success rate by the percentage reduction in their IT budget, while it is important to note that consolidation success rates should be measured another basis of percentage reduction in operational costs. Virtualization complements IT consolidation but cannot replace it. Even after virtualizing, one will still be paying for the maintenance of the same number of application instances, even if they use less equipment to run. As a result, companies frequently struggle to reduce operational costs on the basis of virtualization alone. Direct-attached storage is usually blamed for data centers low storage utilization. However, networked storage can also suffer because of over-provisioning and isolated storage area networks (SANs). One may already be paying for intelligent arrays with virtualization, thin provisioning, or reduplications features waiting to be turned on.

4.4 Improve Data Center Efficiency

Considering the power consumption in data centers, the main problem is the minimization of the peak power required to feed a completely utilized system. In contrast, the energy consumption is defined by the average power consumption over a period of time. Therefore, the actual energy consumption by a data center does not affect the cost of the infrastructure. On the other hand, it is reflected in the electricity cost consumed by the system during the period of operation, which is the main component of a data center's operating costs. Furthermore, in most data centers, 50% of consumed energy never reaches the computing resources; it is consumed by the cooling facilities or dissipated in conversions within the UPS and PDU systems. With the current tendency of continuously growing energy consumption and costs associated with it, the point when operating costs exceed the cost of computing resources themselves in few years can be reached soon. Therefore, it is crucial

to develop and apply energy-efficient resource management strategies in data centers. Data center power and cooling infrastructures should be upgraded so that energy efficiency can be achieved. There are many opportunities to reclaim capacity (and reduce electrical costs) in data centers by making both small and large adjustments. Improving data center efficiency is especially important for large data centers.

4.4.1 Prevent Hot and Cold Air Mixing

When hot exhaust air mixes with cold air, it increases the intake temperature of equipments installed in the data center. This means that it is necessary to set the temperatures even lower, to accept the intake temperatures. It is necessary to isolate the exhaust air with a hot aisle containment system or ceiling to reduce the load on cooling system and increase the power density of racks. Because it is relatively inexpensive compared to new infrastructure, upgrades off facilities to prevent hot/cold air mixing were one of the top choices among the data centers. Before overhauling anything, one should start small improvements like eliminating under-floor obstructions to airflow, plugging cable cut outs, and installing blanking panels in racks (to improve the amount of air delivered to racks). Older, uninterruptable power supplies and power distribution units may have older, less efficient transformers that are responsible for a sizable portion of the wasted electricity in data center. It is important for data centers to replace these older systems with newer, more efficient systems. Most data center infrastructures are network-oriented, allowing collecting usage statistics from a variety of energy management softwares.

4.5 Update IT Processes

Consolidation and virtualization helps to optimize hardware and software investments, reduce the number of systems being managed, and free up or close some underutilized volume servers. However, IT processes remain unchanged and probably are a major source of IT inefficiency. Many data centers are implementing more formalized IT processes, while others suffer from IT processes that have too many steps and depend on manual labor to get them done. Therefore it now becomes obvious for data center managers to revise their IT processes to achieve green data centers. The focus should be on those processes that are most critical to running reliable and efficient IT services; in particular, problem management and incident management issues in data center followed by financial management and configuration management issues. IT processes ensure more reliable services, but with added records and data, formalized processes do not get better efficiency because of the added overhead. The efficiency can be achieved by upgrading the system management tools that integrate with service desk software and provide more task-level automation to free up administrators time.

5. CONCLUSIONS

Green IT is constantly becoming more relevant, and many organizations are working towards reducing the carbon footprint of their data centers. This reduction in carbon footprint is achieved by reducing the data centers power consumption, which in turn results in one being savings for the organization. Many new techniques have been used to achieve this reduction in power. One of them is virtualization. It helps to consolidate multiple servers onto a few physical machines, which increases their utilization, and decreases their power consumption. This paper proposes green IT attributes as solution for implementing green data centers. The proposed attributes provides a solution based on virtualization technology to overcome the issues and challenges of data centers like energy efficiency and CO_2 emissions to reduce the effects of global warming.

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