Best Practices around GREEN IT Data Center: An exploratory Field Study

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ABSTRACT

IT Data Centers are integral part of most of the IT infrastructures. Be it Web Enabled Services, Banking Industry, Government, Finance or Telecommunication, IT infrastructure is typically hosted in a Data Centers. Data Centers can be in-housed or out sourced.Lot of effort goes into the design and implementation of the Data Centers. Many factors are to be evaluated while designing and creating an IT Data Center. These may vary from selecting an appropriate space, flooring, cabling, and false ceiling, providing appropriate power, Air Conditioning, cooling, management, security and more. The IT Data Centers are housed with Servers, Storage and Network components, which form the core of IT infrastructure. Power, Cooling and Space requirements are one of the major factors affecting the design, cost and implementation of an IT Data center of today. Lot of emphasis is being given and various innovative approaches are being adopted to minimize the Power, Cooling and Space requirements for an IT Data center, leading to an energy efficient, environment friendly and economical Green data center. This paper discusses many such design factors and best practices for a Green IT Data Center. The recommendations are based on the inputs received from a field study of two of such data centers, one in India and another one in Europe. These best practices can be used for most optimal, economical and energy efficient IT Management and design of various IT Data centers, including the upcoming State Government Data Centers.

Keywords: Data Center, GREEN IT, State Data Center, Energy efficient, Economical.

1. Introduction

Green IT is not just a trend; it is about eco-responsible Information Technology Solutions. Eco Responsibility includes both economy and ecology, something that is beneficial to the economy and the environment too. With the ever increasing shift to online services, increased use of internet, and corresponding increased demand of backend IT infrastructure, more and more enterprises, both Private and Government are affected by increasing energy costs, cooling problems and space issues in their data centers. It is required to think innovatively and come out with the solution to this problem. Green IT and Green Data Center can prove to be the solution to this problem. In today's IT setups, the infrastructure cost, which includes power, cooling and real estate space, is more than the actual IT hardware and software

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costs. Power costs itself are increasing and may alone surpass the hardware and software costs.

With a billion people participating online today, the network consumes more than 100 billion kilowatts of electricity and costs businesses around $7.2 billion in utility bills annually. And since the power consumption of datacenters doubled between 2000 and 2005, it's no surprise that 25 percent of an IT budget is consumed by energy costs alone. (http://www.sun.com/aboutsun/environment/index.jsp?cid=e4342)

The Internet consumes power as much as 14 power plants, worldwide and CO2-emissions are nearly the same as it is produced by air traffic. And still the data amount increases and forces web hosters to expand their datacenters. (https://cetwo.sfbay.sun.com/display/Onestop/Eco%20Data%20Center%20Solutions)

A new report from consulting company and data center market specialist Broad Group finds that the India market is experiencing substantial growth and will reach more than USD1.5 billion in value by 2010. Yet power supply remains a critical challenge for the country. (http://www.reuters.com)

Clearly there is an ever-increasing demand of IT Data Centers and also increase in associated challenges. This paper highlights the key issues around IT data center design and proposes a few Data Center design parameters and best practices which may be followed in resolving these issues and challenges, leading to a recommended foundational framework for an energy efficient and eco friendly IT Data Center. The observations, learning's and recommended best practices are based on inputs from the field study of some of these state-of-the-art Data Centers, including Sun Microsystems Data Center at Bangalore, India and Prague, Czechoslovakia.

2. Need for the Green IT Data Center

Many Design Parameters have always been considered and are still being considered in designing and implementing IT Data Centers. These design parameters include Reliability, Availability, Serviceability, Scalability, Modularity, Flexibility and Security features.

Keeping in view, the increase in number of users using online services, leading to an ever-increasing demand of compute resources, has lead to an increase in the requirement of Power and Space to host these compute resources and IT infrastructure in, today's data centers. The cost of operating power for servers is to surpass the cost to buy them in next five years. (http://www.sun.com) Today's data centers are running out of power, cooling and space requirements. Power consumption and power densities are rising and the old techniques of power and cooling in a typical, traditional data center are no longer able to cater to today's needs. According to Gartner's Annual Data Center Conference held in November 2006, about half of the world's data centers by 2008 will have insufficient power and cooling capacity to handle emerging high-density equipment. (Meeting tomorrow's data center demands today, NetworkWorld Asia, volume 3, issue 1, Jan/Feb 2007)

Data from the annual EPA report to the US Congress on Data Center and Server efficiency (EPA, 2007) shows that

- Data center energy more than doubled from 2000 to 2006.
- The power and cooling infrastructure accounts for 50% of data center total energy consumption.
- The energy used by the nation's servers and data centers in 2006:
    - 61 billion kilowatt-hours (kWh)
    - 1.5% of total U.S. electricity consumption
    - Total electricity cost of about $4.5 billion.
    - Equal to 5.8 million average US Households

Figure 1 depicts the results in a graphical manner.

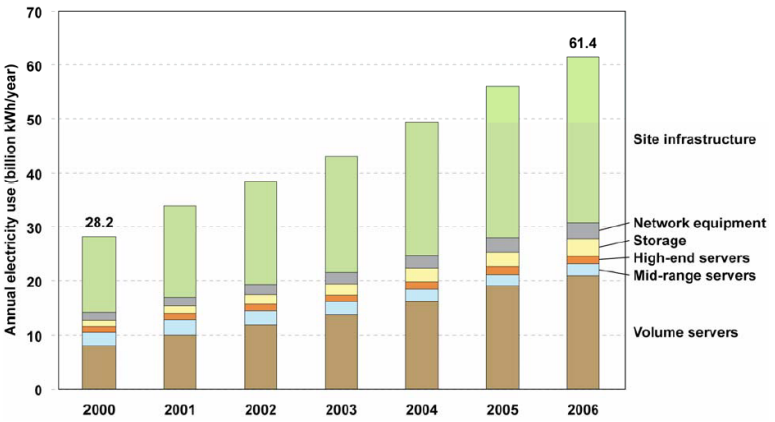

Figure 1: Data Center and Server Efficiency (Source EPA)

Most of the electrical energy in a typical IT Data Center is utilized by the IT Infrastructure which includes servers and storage, also by Chiller units, Centralized Air Conditioners, Uninterrupted Power supplies etc. Some of this is also utilized by the lighting system, Humidifiers, generator sets etc. As stated by APC corp., major components contributing to energy utilization, in a typical data center, are the chiller plants for cooling, the actual IT infrastructure and the UPS Power System. Figure 2 is a pictorial representation of the same. (Rasmussen, APC)

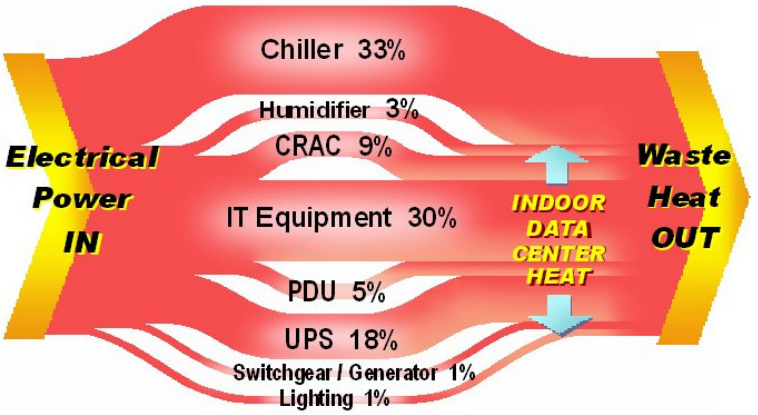

Figure 2: Electrical Efficiency in a Data Center (Source: APC)

Increase in power and space requirement, along with the increase in global warming has forced the IT fraternity to rethink and re-consider the traditional design and implementation approach in the design of IT Data Centers. Typical cooling techniques, of using a centralized air conditioning system, in a traditional data center is not proving to be efficient and sufficient to cater to the needs of today's IT infrastructure demand. Centralized air conditioning and floor cooling is not enough for cooling high loads. The cooling effect remains concentrated and localized to lower heights and cannot cool the overall IT equipment in high density racks of today's data center. A pictorial view to represent the same, as taken from the Uptime institute, is shown in figure 3.

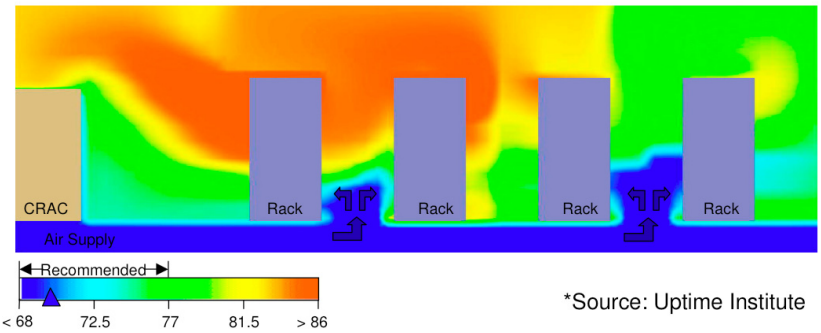

Figure 3: Air Flow in a Traditional Data Center

If somehow, better optimization is done around energy utilization by the IT infrastructure, Cooling and Power, one can bring down the overall energy requirements in an IT Data center. Various innovative and new ideas and best practices are being designed and followed to ensure optimal utilization of Power, Space and Cooling requirements, leading to the birth of Green IT Data Centers, which are eco-friendly. Eco-friendly translates to friendly to the environment and economy.

A Green IT Data Center is designed; keeping in view many design parameters, creating an eco foundation, and leading to a lower Total Cost of Ownership. These parameters range from the Data Center Physical layout and design, Cooling System, Cabling, Power System, IT Infrastructure including servers and Storage and IT design parameters like consolidation and Virtualization for most energy efficient and optimal utilization.

In this paper, we shall discuss each of these parameters and find out how these can be deployed in design and implementation of today's IT Data Center. These design parameters are foundation for the best practices around the Green Data Center and can also be deployed in design and implementation of many of the Government Data centers in India including the State Data Centers across various states.
Many IT Companies like Sun Microsystems, APC and many more have come out with state-of-the-art design parameters in designing and implementing a Green IT Data center. These design parameters are based around

- Scalable, repeatable, modular architecture
- Modular, flexible and optimized power and cooling
- Simplified, flexible cabling and plumbing
- Real-time energy monitoring

The approach is towards using modular, point of distribution cooling and power systems, uniform top-down cooling, simplified cabling and use of eco and energy efficient servers and storage components.
Sun Microsystems, which is global IT giant, and a pioneer in many of the IT innovations, has implemented these principles and best practices in its major IT data centers across the globe, bringing down its power and cooling costs to nearly about 60% (http://www.sun.com/aboutsun/environment/green/datacenter.jsp) The recommendations in this paper are based on the field study of some of those Data Centers of Sun Microsystems, including the ones at Bangalore, India and Prague, Czechoslovakia. Some of these design parameters are discussed in this paper.

3. GREEN Data Center: Design Parameters

3.1 Virtualization and Consolidation

Virtualization & Consolidation are the key design parameters of toady's Green IT Data Center.

Consolidating many servers into one, and virtualizing the application and data can lead to reduced server count, reducing the overall server sprawl, further leading to efficient space, power and cooling requirements, at the same time improving IT infrastructure optimization, and leading to better utilization in a secure and optimized manner.

Virtualization is possible at every level in IT infrastructure, starting from the foundation i.e. The operating system, to the physical servers, storage, Network and even at the client access devices i.e. Client's desktop. Most of the IT vendors are coming up with energy efficient and eco friendly hardware, which includes servers populated with CPUs not taking more than 70 watts of power, which is equivalent to the power of an electricity bulb, with an overall power requirement of less than 500 watts per server. These servers are also space efficient taking maximum of 1 rack unit space and hence leading to an overall best space, power and cooling utilization. Such servers are highly recommended for today's data center requirements.

Most of today's IT servers are bundled with Virtualization technologies, which enable consolidation of thousand of applications into one single server without any performance overheads. These servers have provision to create logical domains, using hyper visor technology, and enabling installation and configuration of heterogeneous operating environments running variety of applications in a space and power efficient single server. This leads to an overall space, energy and power reduction, contributing to the foundation of the Green IT infrastructure. Such servers, bundled with operating system level Virtualization capabilities can further lead to best and most optimal utilization. Sun Microsystems T5000 series servers are one of the best examples of technology around Virtualization and consolidation, leading to 1000's of Virtual partitions, running 1000's of different applications in fault isolated secure virtual machines, all in less than 1 rack unit space, taking about 700 watts of power and generating minimal heat. (Http://www.sun.com/servers/coolthreads/t5140/index.xml)

Vendors like Sun Microsystems, are innovatively designing servers and storage which takes minimal space, consumes less power and generates less heat. The systems are eco-friendly and also economical. The technology based on Chip Multithreaded design virtualizes many processing cores onto one chip, giving best of performance in most optimized power and space factor. These systems perform best on SWaP matrix, which is a measure of Space, Watts/Power and Performance. These systems provide best of virtualization environment, consolidating many servers on one physical box, taking least of Data center power and space.

Virtualization Software's like Sun xVM Server or VMware are also well suited to create a Virtual and consolidated environment.

Such eco friendly servers and storage, bundled with various Virtualization techniques, are best recommended for today's highly demanding IT Data Centers and definitely form an important component of the Green IT Data center.

Global IT giants like Sun Microsystems have used such technologies to bring down the Power, Cooling and Space requirements in their Data centers and have achieved amazing savings. These Data centers have done Consolidation and Hardware refresh with the latest energy efficient servers, that has enabled hosting of many applications in lesser number of servers, reducing the requirement of Power, Space and cooling, leading to an overall reduction in cost. Some of the factual figures highlighting this achievement are cited here.

- Data Center consolidation and hardware replacement efforts enabled Sun to reclaim 88% of its Data Center floor space, reduce power consumption by over 60% and avoid more than $9 million in construction costs. (http://www.sun.com/aboutsun/environment/green/datacenter.jsp)

- Sun used the energy efficient, eco responsible servers along with innovations in power, cooling, cabling and rack design to consolidate 13 labs at its India Engineering Center (IEC) in Bangalore into a State-of-the-art datacenter. Consolidation at the Sun Bangalore R&D Data Center reduced power consumption by 17%, Space by 51% and at the same time increased the compute capacity by 154%. (http://www.sun.com/aboutsun/environment/green/datacenter.jsp)

Such best practices, for Consolidation and Virtualization should definitely be adopted by the upcoming Data Centers.

3.2 Cabling

Consolidation and Virtualization, as discussed above, leads to reduction in usage of Data Center space, by densely populating various systems in less number of racks, but this at the same time leads to cabling issues. Connecting may of those systems in smaller footprint, may lead to a jungle of cables! This may require raising the floor size to accommodate the plenum Cabling. This can further block the airflow and lead to cooling issues further leading to downtime and Data center outages. With the increase in density of servers per rack, the number of cables also increases. Table 1 shows these values. (Connecting Energy efficient data Center, www.sun.com)

Table 1: Cabling Densities per rack

Server Size	Number of Servers per rack	Number of Cables
18 RU	2	21
2 RU	20	145
1 RU	40	285

In a traditional Data Center, all the cables from various racks, spanning across the complete data center, terminate on to a central unit. Even the Management cables, and control cables are routed to a central panel. This leads to inefficient and difficult to manage setup.

Innovative Cabling techniques and use of standardized cables is needed to avoid this issue. Separation of Data and Electric cables is also needed to avoid interferences. Sun Microsystems Data Centers, under this study, have used these techniques partnering with CommScope and using SYSTMAX Solutions. (http://www.commscope.com/systimax/eng/index.html)

The approach is to create a flexible, modular, scalable and easily serviceable design. Instead of a centralized Intermediate Distribution Frame (IDF), a pod (Point of distribution) concept is used. Intermediate Distribution Frames are created for a group of racks in the data center; each pod is connected to the centralized IDF using high-speed 10GbE fiber uplinks. This leads to a flexible design, ready for future. The design achieves many benefits like flexible configuration, including changing, modifying or enhancing the requirement as on need basis. Easy management, independence from lock-in to physical position of racks etc, also accompanies this.

3.3 Power Requirements

The requirements in terms of IT infrastructure are very flexible. Most of the Data Centers are designed keeping in mind the present and long term requirements, but these requirements change with the change in user's requirements, change in number of users, change in number of services and also change in the user's demands. As an example the State Data centers in India are being designed, keeping in mind the present and near future requirement. But if most of the citizens start using the online services and also the State decides to put more and more services online, the requirement and need will change, this will lead to change in IT infrastructure requirement, further leading to change in power requirements, cooling and cabling needs etc.

Going by the traditional design techniques, a typical data center may not be ready to accept these changes, and one may have to redo or recreate the complete data center, with the changing needs. Some of the innovative techniques followed by Sun Microsystems data centers, which were studied in this field exercise, is to design and use flexible, modular and adaptable power system. This is a pod (point of distribution) based design, which takes care of changing needs of a data center. Data center requirements may change from time to time and these changes may include IT equipment refreshes, equipment relocation, higher power and or different power outlet requirements etc. Implementing these changes in a typical data center, may lead to a change in power circuitry, cabling etc which may prove to be expensive and inflexible.

POD based design avoids these complications. POD is a self-contained group of racks that optimizes power, cooling and cabling.

Sun Microsystems Data Centers, under this study, have used innovative designs in collaboration with Universal Electric and APC electric systems. The racks, which are populated with the servers or rack mount storage, scale from 4KW /rack, in units of 4KW, up to 30 KW/rack. The POD based design in these data centers, uses, redundant Starline track bus-ways from Universal electric, which distributes power to each POD. These bus-ways carry fewer cables ie less copper, leading to tremendous cost savings, and are powered by electrical distribution boards, which may be outside or inside the data center. Each POD has drop cables and circuit breakers. This implies each POD can be isolated and easily managed for servicing purposes; new PODS can be provisioned without disturbing the existing ones. The design is flexible, modular and easily serviceable. These PODS can also be monitored, for power consumption and usage. This further helps in trending and analysis and ultimately efficient and effective utilization, at the same time leading to reduction in human errors and most optimal Space Utilization.

Sun Microsystems Data Center at Prague is using APC UPS. These UPS's are modular, flexible, and easy to deploy, re-deploy and grow. The data centers are provisioned for about twice the capacity of the present requirement, ensuring seamless scalability in future. The design is again POD based. Distribution of power from the UPS is to each POD in the data center.

The UPS design is modular and very efficient, it is easy to install, easy to add additional modules, easy to re-deploy from one place to another, has modules, which can be easily repaired. There is a provision for online monitoring, which leads to better planning and distribution of load. (Powering Sun's energy efficient Data Centers, www.sun.com)

3.4 Cooling Requirements

High Density racks with Consolidation leads to many systems per rack, and traditional cooling systems, with a Computer Room Air Conditioner (CRAC) or raised floor cooling is not adequate for the cooling these high density consolidated systems. Raised flooring, with floor based cooling which has been a traditional method of cooling the data centers, cannot suffice the needs of today's ever increasing high density IT infrastructure racks. This traditional technique leads to unpredictable cooling patterns, and humidity problems.

Sun Microsystems Data Centers under this study have again used an innovative technique of point cooling or POD based cooling. Point Cooling is a technique to provide cooling, where it is actually required. This leads to cooling the actual rack area, where maximum heat is generated, without increasing the cooling in other areas within the data center.

Sun has used APC and Emerson's innovative design techniques, to create modular, flexible, and scalable, energy efficient, and easily serviceable POD cooling design. APCs InfraStruXure In-row cooling and

Emerson's XD (Extreme Density) heat removal techniques have been used. These techniques decouple the room cooling from rack cooling and provide efficient cooling where it is needed the most.

In-row rack cooling units have network management cards which helps to manage and monitor cooling across the data center. Emerson Libert XDV Vertical top cooling modules are placed above the racks, XDV coolant from XDV Chiller is passed through the coolant circuit, providing cool air to the front of the racks, the heat generated from the rear of the racks, increases the return air temperature, leading to more efficient heat transfer within the cooling unit. This in turn decreases the equipment fan speed, and hence saving energy.

This technique does not require raised flooring or air flowing under the floor.

Figure 4 shows the POD design at Sun Microsystems Prague Data Center.

Figure 4: POD (Point of Distribution) Design in a GREEN Data Center

4. Top Ten Best Practices around a GREEN IT Data Center

Based on the inputs from this field study and recommendations by various vendors, following is a summary of Best Practices, which should be adopted for designing, implementing and managing a GREEN IT Data Center. These can be very useful for the upcoming State Data Centers in the country, in creating economical and ecological IT infrastructure.

- Consolidate many distributed servers into smaller number of easily manageable servers. This will reduce the footprint as well as power and cooling requirements.
- Select smallest rack unit, high density, less power consuming and energy efficient eco servers. Measure them on SWaP. (Space, Wattage and Performance)
- Virtualize at all levels - Servers, Storage, Operating environment, Network and the Client. This will lead to best utilization, at the same time reducing power, space and cooling requirements.
- Use POD based design. POD is Point of Distribution, a self-contained group of racks that optimizes Power, Cooling and Cabling.
- Use PODs for Power distribution; this will lead to flexible, modular, adaptable, space efficient, and easy to grow power distribution mechanism.
- Use POD for Cooling, with point cooling techniques like cooling in-row or cooling from top and not through a raised floor cooling mechanism.
- Use POD based distribution for cabling using standards based cabling.
- Use Monitoring mechanisms to monitor power and cooling, leading to online management, analysis and trending for the present and future power and cooling requirements.
- Use appropriate Fire Control mechanism. Most fires in mission critical facilities can be prevented

if common mistakes are avoided and fire detection is properly specified and monitored. Human error plays a large roll in preventing fire hazards and must be eliminated through training and procedures that are enforced. (Avelar, APC)

- Deploy appropriate Humidity control systems.

5. Concluding Remarks

In today's IT world, there is an ever increasing demand of online services, leading to increase in demand of IT resources like servers, and storage which are hosted in an IT Data Center. This is further leading to an increase in the demand for power, cooling, space and cabling requirements to host these IT resources. Traditional Data Center design techniques cannot cater to these ever increasing, unpredictable demands.

A modern Data Center, which efficiently utilizes power, Space and cooling and has modular, flexible and scalable architecture is the need of the hour. This is the GREEN IT Data Center which uses techniques like Consolidation, Virtualization, and POD based modular, flexible, Scalable and repeatable power, cooling and cabling design. These design parameters and best practices around them have been discussed in this paper. Upcoming Government Data Centers, including the State Government Data Centers, should adopt the best practices and design parameters around a GREEN IT Data Center, for creating an economical and ecological IT infrastructure, which is good for the country and the environment.

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