2011

INDIAN INSTITUTE OF
MANAGEMENT-KOZHIKODE

[GREEN COMPUTER CENTER]

Team Members:

1) Krishnadas N
   Email: username.krishna@gmail.com, krishnadasn02fpm@iimk.ac.in
   Mobile: +91 9048240816
2) Supriya Nambiar
3) Ram Kumar Dhurkari

Table of Contents

Abstract

The project is about Greening the Computer Architecture of the institute with more than thousand computers and bringing down the carbon emissions emitted by organization's IT wing. This project attempts to review the computing practices at computing center of Indian Institute of Management-Kozhikode and come up with a strategic plan for implementation of Green IT. The implementation aspect involved concepts like benchmarking, cultural aspects, regulatory measures, energy of data centers, cloud computing, videoconferencing, e-waste, duplex printing, virtualization and Green IT procurement.

A study was conducted to keep track of the idle /underutilized computing resources by the students/faculty/staff and improve the efficiency of the system by implementation of a pilot grid application. The time period of the project was close to four months and substantial reduction in the carbon emissions could be obtained. This project mainly involved the staff at computer center, the IT Department and faculties supporting the project. The initial phase of the project started with providing justification to the computer administrators to invest in Greening the Computer Center. It involved some research on cost-benefit analysis to prove them the worth of implementing Green IT in the computer center. The advantages were not only limited to the reduced carbon emissions but potential savings in IT cost of the institute.

What is Green IT?

It is important to understand the concept of sustainability before understanding Green IT. Sustainability is defined as “development that meets the needs of the present world, without compromising the ability of future generations to meet their own needs” (WCED 1987, p. 43; Brundtland, 1987). Present focus of many IT organizations/computing centers today is the triple bottom line by satisfying the sustainability of economic, social and environmental capitals simultaneously (Dyllick and Hockerts, 2002). Ecological sustainability looks upon long term survival of individual/group and deserves a higher priority than sustainable economic development (Starik and Rands, 1995).

Green IT has recently gained importance owing to its noble cause to green the environment with added benefit of its ability to reduce the unwanted costs associated with IT implementation in organizations. This dual advantage has forced organizations to adopt Green IT practices and come up with results which can considerably reduce the environmental impact and gain profits.

Green IT is a synonym to environmentally sound Information Technology (Murugesan, 2008). It includes multiple aspects like environmental sustainability, energy efficiency economics, cost of disposal/recycling etc. Broadly, there are two sides of Green IT; one dealing with IT being the cause of environmental problem and the other using IT/IS to solve the environmental problems. It captures the **technical capability** including choices related to applications, data, technological configurations etc (Broadbent & Weill, 1997) as well as human/managerial capability including experiences, competencies etc of IT personnel (Byrd & Turner, 2000).

Four domains of Green IT has been proposed by Murugrsan, 2008. They include Green use, Green design, Green manufacturing and Green Disposal of IT Systems. Green use is all about reducing the energy consumption associated with the computing resources and use them in an environmentally sound manner. Green disposal deals with the issues of refurbishing and recycling old computers and electronic equipment. Green design focuses on designing energy efficient components, servers and cooling equipment. Green manufacturing is a step of implementing Green practices right at the manufacturing stage with minimal impact on environment.

According to a survey conducted by Sun Microsystems on Green IT, there were different aspects that organizations wish to achieve via Green IT implementation (Figure-1). The top of the charts were reduction of power consumption and lowering of costs. While environmental concern plays an important role in implementing Green IT, improved system performance and space settings also act as potential reasons for Green IT implementation.

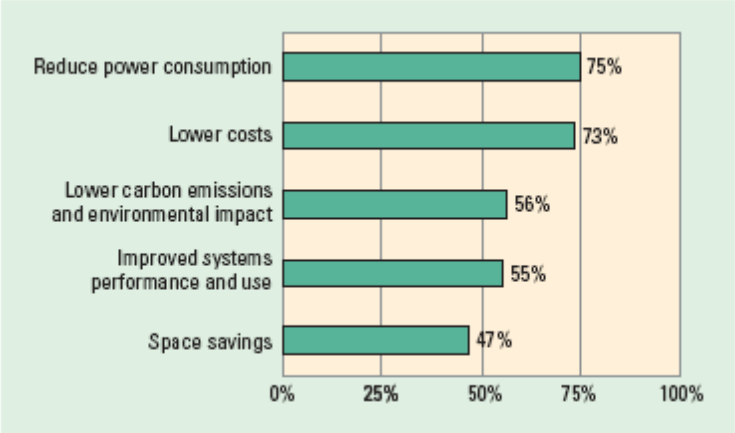

Figure 1: Sun Microsystems Survey, benefits of Green IT

Green IT and IT Infrastructure:

IT infrastructure plays a strategic role in an organization (Weill and Broadbent, 1998).It basically refers to the support systems that are shared among users at different levels and functions (Broadbent *et al*., 1996; Turnbull, 1991). The IT setup at IIMK comprises of a multi layered architecture, the lowest layer of which is made up of personal computers and workstations. The next layer consists of File servers and Database servers. The third layer consists of Web server, FTP server, Email server and other high-end servers/computers required high resources demanding tasks. All the buildings including hostels in the campus are part of the campus LAN and all the services available on the LAN can be accessed from any node. The entire campus has been Wi-Fi enabled to provide mobility to the users in accessing various services available on institute's network. All the buildings in the campus are interconnected through a 6 core SMF Gigabit Fiber Optic backbone. The connectivity to Desktops is using 4 pair ECAT 5 UTP cable ensuring a dedicated 100Mbps bandwidth at desktop level. The computer centre acts as the main hub of the network and hosts a layer 3 backbone switch. The workgroup switches are located in the respective buildings. All the hostel rooms are also connected to the campus LAN. The summary of the infrastructure is presented in Figure-2.

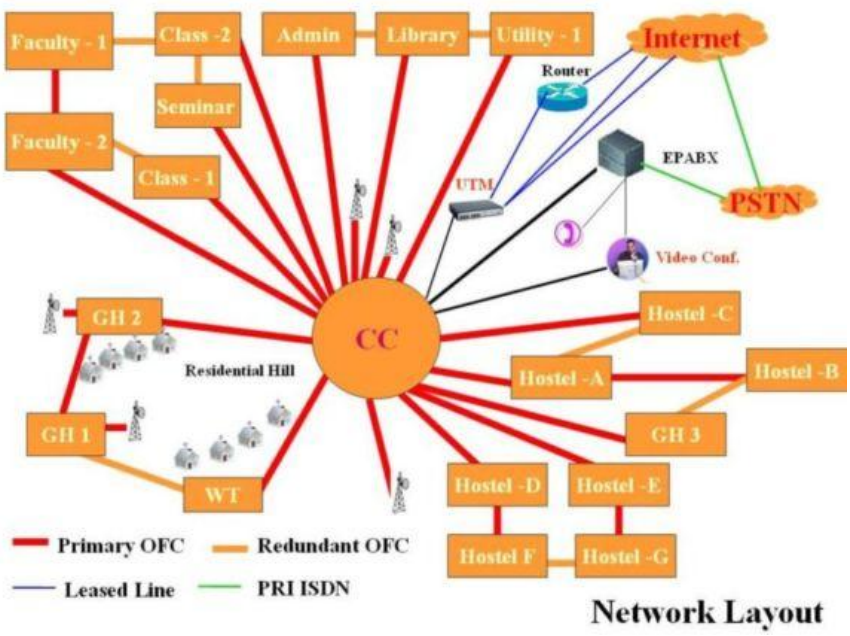

Figure 2: IT Infrastructure at IIM Kozhikode -Source: IIMK Website, http://www.iimk.ac.in/infrastruct/campusnetwork.php

Interviews with IT managers at the computing center revealed the present status of Green IT. It was found that the organization had no special initiatives towards environmentally sound computing. The computing center was adhering to the environmental standards and purchasing the hardware that is ecologically certified. One step towards the reduction of commuting cost is the usage of high tech rooms equipped with state of art ISDN and IP based videoconferencing facilities. The organization looks for implementing measured beyond the compliance to laws and hence this paper attempts to provide a strategy for the same and implementing some aspects of Green IT

Project Details

The initial stage consisted of studying the present computing practices and presenting the organization with a strategy for Green IT implementation. After presenting the strategy, Grid Computing was implemented as a part of Green IT initiative. This study required a ubiquitous presence of environmental concern across all the departments. It required incorporating sustainability practices and awareness in research, teaching, consultancy and social development projects. The strategy proposed in this paper looks upon both long term and short term strategies. It reviews present practices at the computing centers along with understanding of the computing practices followed by staff/students. These reviews set the ground for Green IT implementation at the computer center.

The strategic plan includes concepts like benchmarking, cultural aspects, regulatory measures, energy of data centers, cloud computing, videoconferencing, e-waste, duplex printing, virtualization and Green IT procurement. A pilot study was conducted to understand the idle times and under-utilization of computers at the computing center. This was followed by implementation of grid and analysis of the utilization of system resources thereafter.

Stage-1: Setting up the base for Green IT initiatives

Interviews with IT managers at the Computing Center revealed the present status of Green IT. It was found that the organization had no special initiatives towards environmentally sound computing. However, the Computing Center was adhering to the environmental standards and purchasing the hardware that is ecologically certified. Also, it had taken a step towards the reduction of commuting cost by the usage of high tech rooms equipped with state of art ISDN and IP based videoconferencing facilities.

Stage-2: Proposing the Green IT Strategy

The strategic plan suggested in this section is an outcome of understanding the computing trends at the computer center via interviews with key management people. A thorough study of the existing green IT practices was conducted and the Green IT practices in various organizations like IBM, Cisco, and Microsoft etc were reviewed. The remainder of the section identifies a range of strategies including both short term and the long term ones.

Benchmarking: It is defined as means of estimating the system performance by using multiple workloads and measuring the performance. It is used as a means to determine the best equipment to buy in various technology insertion cycles, when the standards/recommendations regarding computer hardware procurement is concerned. This step remains pivotal in setting up environmental objectives/targets for an organization to reduce its environmental impact of computing.

Benchmarking can be used by computer center to measure its carbon footprints and set its carbon emission reduction goals. Direct and indirect emissions should be included in the design of metrics and models required to incorporate benchmarking and transparency. This has been one of the top priorities of organizations looking to implement Green IT in their organizations. There are various calculators available to give a rough estimate of carbon emissions. A basic version of Microsoft's Green IT calculator was used to give a start to the benchmarking process (Advanced calculators are available for detailed study). This calculator is used only for the desktops; there are different calculators available for servers. The inputs for the same are documented in Table 1 while the output shown by the calculator is shown in Table 2. The graphical representation of the calculator is shown in Figure-3.

Table 1: Inputs for Microsoft Desktop Energy Savings Calculator

Desktop Energy Estimates: Inputs	
Number of PCs	500
LCD Usage	76%
CRT Usage	24%
Desktops	100%
Notebooks	0%
Windows XP	77%
Windows Vista	3%
Other Windows	21%

Table 2: Output, IIMK Annual Consumption

Desktop Energy Estimates: Output	
Power Cost	$46,278 per year
Power Consumed	473,676 kW/h
Carbon Emissions	367.1 tons
Equivalent number of automobiles	67.2
Equivalent no of homes	39.4
Equivalent number of trees	797.7

Figure 3: Results of Microsoft Energy Savings Calculator -Source: Microsoft Green IT Website (Inputs from IIMK), http://www.microsoft.com/environment/greenit/Preview.aspx?type=desktop

Green culture/engagements: This section focuses its efforts specifically on the organization under study. Studies have demonstrated the importance of organization culture in green business. Cultural factors should focus on the three important aspects of- a) Individual attitude towards Green IT b) Subjective Norm towards Green IT and c) Perceived Behavioral Control towards Green IT.

Education of green IT practices at IIMK is one of the most important aspects of altering the culture. Proper understanding of the roles and responsibilities along with integration of sustainability with strategic objectives will lead to smooth implementation of Green IT. Therefore, it is important for a cultural change and engagement with the business school community. Key points include a) Establishment of a steering committee with appropriate charter and across business school membership. b) Education on Green IT practices using the organization's web site, starting a blog on the same. c) Providing equation that permits the staff

to calculate individual carbon footprint at work, thereby increasing the motivation. d) Encourage staff to innovate using Green IT practices.

Regulatory Obligations: IIMK already adheres to the regulatory measures. However, both the international and Indian environmental regulations keep on changing over a period of time. A framework can be developed for working with compliance to regulatory measures. This framework should be continuously monitored to ensure that IT is constantly meeting its requirements.

Data Centers: The aim of the organization should be to deliver green energy efficient and accurate computing for the coming years. Key points include a) Use of liquid cooling (far more efficient than air cooling) for substantial cost savings; however it needs careful implementation. b) In case setting up new data centers, use of high density servers is recommended which use hydrogen fuel cells as alternative green power sources. c) Purchase of smart plug strips that does not need power to reach them unless they are being used and it reduces the carbon output by around 290 pounds. d) Look forward for shared data center initiatives with other educational institutes e) Using virtualization to consolidate f) Procurement of green data equipments and choosing effecting design in case of new data center.

IT Architecture: This strategy aims at suggesting an environmentally sound IT architecture in the computer center of the organization. Many organizations look for no architecture approach to do away with the ramifications of managing IT architecture (Cloud Computing).

There are two important highlights of this strategy: cloud computing and thin clients. In cloud computing, customers pay for the computing resources by means of customized service level agreement hiding the underlying technological infrastructure. Cloud computing analysis was conducted using the cost-benefit model and it was found that there is substantial cost savings for the Computer Center.

The second component is the introduction of thin clients. It is recommended for greening of data centers as it leads to reduction of complexity and cost. They have longer life span and require fewer raw materials to build on, thus reducing the environmental impact. Thin clients consume 6.6 watts of energy compared to desktop that consumer up to 150 watts. There are 500 PC’s installed in the institute. If each PC can save around 140 watts by implementation of thin client PC, total energy savings in the organization would be 70,000 watts. This would bring

down the power usage to a considerable extent. Smaller than desktops or notebooks, thin clients also require fewer raw materials to build and typically have a long lifespan of seven to eight years, which lessens their environmental impact, according to Wyse Chief Marketing Officer Jeff McNaught. In addition, thin clients don't need fans, make no noise and generate less heat, so it has no impact on office temperatures, and therefore, air-conditioning costs are lower.

E-Waste: E-waste comprises electronic equipment such as computers, entertainment electronics, and mobile telephones that have been discarded by users. It is one of the fastest growing waste streams in the world and accounts for .01% to 1% of the total municipal waste generation. This organization had recently revamped its computer center by changing the CRT monitors to LCD and bringing in fast processors. They outsourced the burden of e-waste to the vendor who installed the new infrastructure. The present strategy is sound; however the future ones might include a) reviewing procurement/recycling policies and procedures b) Adoption/expansion of life-cycle management strategies and look for products with design that is apt for recycling.

Printing: Gartner suggests that active print management initiatives can cut your office print costs by up to 30%. Printing is one of the major concerns with the amount of paper wastage in the institution. Present infrastructure uses networked printer which does not support duplex printing. Key points include a) Use of duplex printing that would reduce the paper usage by 25% b) This should be supplemented by installing effective tools like HP Universal Print Driver for proper support on duplex printing c) Further the use of recycled paper by properly maintaining the used papers.

Green IT procurement: Since the aim of the paper is to come up with both long term and short term strategy of Green IT implementation, it is necessary to consider environmentally sound IT procurement. The procurement practices at the computer center must consider energy efficient equipments that could lead to dramatic reduction of electricity charges. Key points include: a) Life cycle management for procurement/supply b) Sourcing products/services through low carbon directory c) Procurement in data centers should keep into account the virtualization and consolidation aspects

Stage-3: Utilizing the system resources efficiently: A pilot study

Computer Center decided to implement Grid Computing to start with Green IT implementation. However, they asked for economic factors associated with Grid Computing. The demonstration

of the under-utilization of present computing resources acted as a strong motivating factor in favoring the intention to implement Grid computing.

This demonstration involved monitoring the number of times a typical user goes idle and the time duration of the same. Idle time is defined in this paper as any inactivity for more than 30 seconds. This would be an appropriate measure because the systems monitored were in the computing center of the B-School, where the usage of videos is not encouraged. A user can perform no activity for more than 30 seconds and still be active only in special cases like watching a video.

A VB application was developed and installed in all the systems being monitored. This application records the start/end time of monitoring along with the number of times a system goes idle. It also notes down the extent of time to which the system remained idle in each case. Hibernation mode and 'log-off' modes were not considered because they already have power savings mechanisms. Hence, these states cannot be attributed to underutilized computing resources (Lock state was taken into account). The details recorded in the database for a sample user is shown in Table-3.

Table 3: Idle Time recording of a sample user

Start time	1:17:38 AM
End Time	9:47:14 AM
Idle Count	**Idle Time**
1	30.05
2	64.58
3	47.05
4	94.61
5	187.56
6	23804.91
7	5833.7

The data of all the users were aggregated to gain insights on two parameters. The first being the average number of times a user goes idle per hour. Secondly, the average time for which the system remains idle each time it goes into the idle state. The summary of results is shown in Table-4.

Table 4: Results of study, Phase-1

Number of sample cases	25
Total of Idle count per hour across samples	135
Average idle count per hour	5.4
Average percentage of time the system remained idle	57.78%

Results reveal that more than fifty percentage of the time the system remains idle. This excludes the time during which the system has been logged-off. If it were to be included, the percentage of time the system remains idle would have been higher. This study reveals the acute need of using technology to utilize these idle times and contribute to the green computing. Therefore, a small application using grid setup was implemented in the computing center of the business school.

Stage-4: Grid Computing Implementation

At the last phase of the study, grid computing was implemented. This part of the study involved execution of an application that required intense computing resources. This application used the open source .NET based framework of Alchemi and its libraries for development. Alchemi provides the runtime machinery and programming environment required to construct grids and develop application.

Project Implementation Highlights

Unique Features:

This project involves a lot of research to be done for proper implementation and hence stands out from other sustainability projects. Moreover, the pollution from computers is not clearly visible and hence it is tough convincing and educating the stakeholders involved as to why Greening of Computer Center is so important. This project involved moving from legacy systems to Greener systems like servers to Cloud, simplex printers to duplex printers. Thus, this was not an incremental change; it was rather radical change which involved research work to prove the returns on investment. However, the most important part of this project is its replicability at other institutions. Almost all academic institutions have a computer center and they can follow a similar methodology to make their computer center greener and pollution free.

Making the output available to Public Domain:

The research papers associated with this project will be published in reputed journals and conferences and hence available to public. Almost all universities have a computer center and would face similar problems in implementing Green IT. This project would give guidelines on benchmarking their computer architecture with respect to the carbon emissions and help them in overcoming the hurdles likely to be faced. Moreover, this project has earned substantial reduction in carbon emissions and IT costs as a potential output and hence can be used as an example for other universities.

How it differs from other projects at the University?

There are several dimensions on which this project could be termed unique when compared to other projects. First dimension is the scale at which the project was executed. The stakeholders involved in this project almost spanned the entire university starting from students/faculty (their PC/laptop usage was studied) to director/administration (approval and funds for implementation). Secondly, this project involved a lot of awareness/education about the carbon emissions and environmental impact of computers. As the harmful impact of computers is not tangible, efforts were made to educate the stakeholders about Green IT. Lastly, it was the research work involved that makes this project noble and shows the practical implementation of research in a university.

Challenges

As already mentioned, the major problem was educating the stakeholders regarding the environmental impact of computers. Also, one drawback with the project is that one cannot demonstrate immediate results. For a project that involves Greening, the returns are generally seen after a long period of time. Hence an important challenge in this project was to show immediate returns after the successful implementation of Green IT in the computer center. Also, it involved studies to prove that the present infrastructure had inefficiencies and that the environmental impact of computers was potential. This project involved replacement of heavy and costly devices like printers and processors. Hence, an effective method of replacement and environmental friendly disposal of such systems had to be worked upon.

Work done so far:

- Power Management Schemes ensure proper shut down of the system thus reducing electricity bills by 20%
- Printers are replaced by Duplex Printers thus saving Paper Cost by a whooping 60%
- Using Grid Computing to utilize idle system resources thus increasing the efficiency of the systems by 35%
- Finished the ground work for moving to Cloud Computing
- Laid out the long term Strategic Plan for Green IT in the computer center

Conclusion

This paper has thus come up with a detailed strategic plan for the implementation of Green IT at IIMK. It has understood the current environmental impact of the computing architecture and thus implemented some aspects of Green IT to move towards a Green Computer Center. A pilot study was conducted to determine the feasibility of making use of grid applications. It was found that it results in substantial reduction in the underutilization of the computing resources. Further research would include empirical study of other strategies proposed like the virtualization techniques in data centers. This strategic plan could act as guidelines for any organization looking to implement Green IT. We anticipate a 50% reduction in energy usage after complete implementation of the study. All energy used will be generated sustainably and the computer room will become CO2 neutral.

The future of this study lies in transcending this project from green computer center to sustainable campus. Firstly, our team would like to get a holistic view of environmental sustainability research by understanding diverse areas including water/waste management, biomass/bio-fuels, landscape management etc. We would like to visit universities abroad where they have implemented similar initiatives and get a platform to learn practical implementation at a macro level and thus, we could effectively share and implement Green Practices in India.

References

Broadbent, M. & Weil, P. (1997). Management by maxim: How business and IT managers can create IT infrastructures. Sloan Management Review, 38(3), 77–92.

Broadbent, M., Weill, P., O'Brien, T., Neo, B.S. (1996), Firm Context and Patterns of IT Infrastructure Capability. Proceedings of the Seventeenth International Conference on Information Systems. New York.

Brundtland, G.H. (1987), Our Common Future: The Report of the World Commission on Environment and Development, Oxford University Press, Oxford.

Byrd, T. A. & Turner, D. E. (2000). Measuring the flexibility of information technology infrastructure: Exploratory analysis of a construct.Journal of Management Information Systems,17(1), 167–208.

Dyllick, T. and Hockerts, K. (2002), ''Beyond the business case for corporate sustainability'', Business Strategy and The Environment , Vol. 11, pp. 130-41.

Murugesan, S. 2008. Harnessing Green IT: Principles and Practices. IT Professional 10, 1 (Jan. 2008), 24-33. DOI= http://dx.doi.org/10.1109/MITP.2008.10

Starik, M. and Rands, G.P. (1995), ''Weaving an integrated web: multilevel and multisystem perspectives of ecological sustainable organizations'', Academy of Management Review, Vol. 20, pp. 908-35.

Turnbull, P.D. (1991) Effective investment in information infrastructures. Information and Software Technology, Vol 33, No 3.

WCED (World Commission on Environment and Development). 1987. Our Common Future, Oxford, UK: Oxford University Press.

Weill, P. and Broadbent M. (1998) Leveraging the New Infrastructure: How Market Leaders Capitalize on Information Technology. Harvard Business School Press. Boston, Massachusetts.