International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 1, January- 2013

Green Learning: Appraising Power Consumption for WBL Environment

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Abstract

Rapid advancement in Information and communication Technology (ICT) has enabled people to learn anytime anywhere. E-Learning refers to learning digitally through Web-based Learning (WBL), Computer-based learning (CBL) and Virtual Classrooms. Large data centres located worldwide have made Learning Management Systems (LMS) reliable and accessible. But, these data centres consume lot of energy. The purpose of this paper is to appraise the energy implications and to analyze energy requirement from user and server end for online learning. We put forth our suggestions for making the online learning further 'Green'.

1. Introduction

During the advent of computers, the research focus was on improvement of technology, both in terms of hardware and software. Over the past half century the hardware efficiency has improved tremendously to encourage software application development over multiple platforms. The storming of Web-based applications has encompassed all fields. The accessibility, availability, reliability and usability factors has made these applications human friendly. This in turn has led to a surge of IT equipment use from the traditional CRT based desktop to Laptops to Tablets.

Irrespective of the mode of technology, media and method of usage, these equipment demand constant energy. Equipment, in turn is fed by subsidiary equipment, building a chain of suppliers and consumers. Tracking the power supply to a Home PC, we see that it is fed by the network of power lines, switches, transformers from a power station. Electricity is a secondary source of energy unlike coal, petroleum or solar energy. Hence, technologists and researchers are now focusing on energy reusability, power saving techniques, cost effective methods and eco-friendly substitutes to ensure energy sustainability. The Green IT approach emphasizes on environment friendly utilization of IT and its infrastructure.

In the next two sections, we present a brief outline on Green IT and e-Learning. In section 4, we discuss the energy issues relative to e-Learning and storage at data centres. We conclude by summarizing our observations and putting forth some suggestions towards energy conservation.

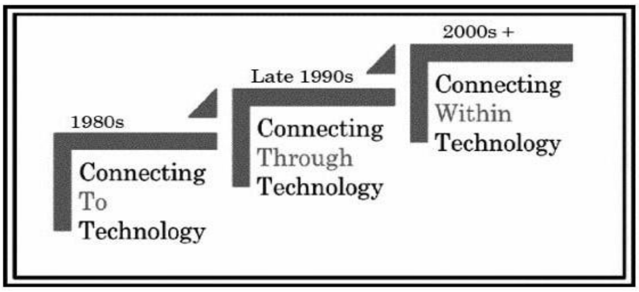

Fig 1. Evolution of Enabling Technologies for Green Computing [6].

2. Green Information Technology (IT)

Green IT refers to environmentally sound IT. It's the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems—such as monitors, printers, storage devices, and networking and communications systems—efficiently and effectively with minimal or no impact on the environment [9]. Green IT also strives to achieve economic viability and improved system performance and use, while abiding by our social and ethical responsibilities (Fig 2 [9]). Going "green" with technology would imply using technology in an ecologically friendly way without breaching the natural resources or utilizing the natural resources in such a way that we do not deplete it.

Many businesses and organizations have of late realized the impact of utilizing technology for the most mundane of things. Though technology has been a boon in general, the off shoot of problems on the general well-being of the nature and the earth as a whole cannot be ignored. To mitigate the side effects of technology, Green IT focuses on methods to decrease waste and pollution generated during the life cycle of technology gadget and software utilization.

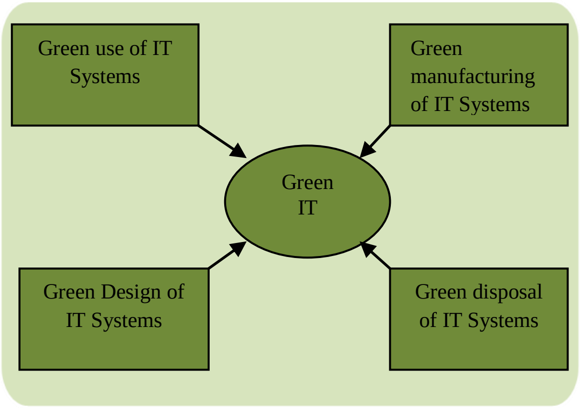

Fig 2. Holistic view of Green IT [9]

3. E-Learning

Currently, trend in primary, secondary and tertiary education has been the use of ICT for education, more commonly known as e-Learning. Corporate training is being undertaken mainly through e-Learning to reduce the cost of training, provide convenience of learning to employees at their own time. Use of Learning Management Systems (LMS) or Learning Content Management Systems (LCMS) has enabled the employers to constantly support the employees' training requirement, modify the content as per the skill set requirement and also monitor the progress of learning of the employees.

3.1. ICT, Education and Environment

Provision of education through ICT is aided by the use of data centres. Data centres offer dedicated facilities through servers over a network. These data centres may also be on a cloud (a neo-migration in data storage) used by businesses, educational institutions and governments. Gartner report, "Forecast: Enterprise ICT Infrastructure Energy Consumption and Carbon Emissions, India, 2006-2015", states that energy consumption by India's enterprise ICT infrastructure stood close to about 4% of the country's overall consumption and accounted for about 2% of the country's overall carbon emissions in 2010. They forecast that these emissions will grow at a compound rate of 6.5% and 6.3% respectively through 2015 [11].

The benefit of e-Learning has accentuated the usage of WBL worldwide. Fig 3 provides an overview of the growth of online learning in higher education from 2002 to 2008 [11] and our projected estimate in 2015. The project is seen to be increasing steadily.

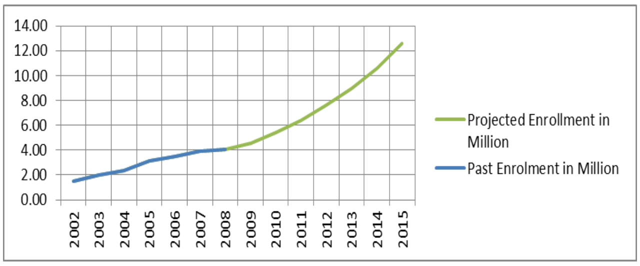

Fig 3. Online learning Growth-Projection. (An estimated projection based on [11]).

The huge prospect of growth and revenue, no doubt, is an attraction for businesses, training centres and universities to plunge into online learning model. What are the pros and cons of online learning on the environment? How green or eco-friendly is this mode of learning? IT now causes the release of as much carbon dioxide into the atmosphere as nearly 320 million cars. According to calculations by consultants A.T.Kearney, worldwide IT now generates CO_2 emissions about 600 million metric tons a year. [14]. Hence, in the next paragraph, we discuss on the 'greenness' of ICT.

Today, global-scale online services typically run on hundreds of thousands of servers spread across dozens of data centres worldwide [2]. In 2009, [8] Google was estimated to own over a million servers. As cloud computing model matures, the scale is sure to increase. The online model of learning means courses are stored in data centres across the world. Data centre energy consumption is also of concern due to its significant environmental impact. Studies show that combined electricity use of internet and cloud (data centre and telecommunication network) is growing at a rate of 12% annually [3].

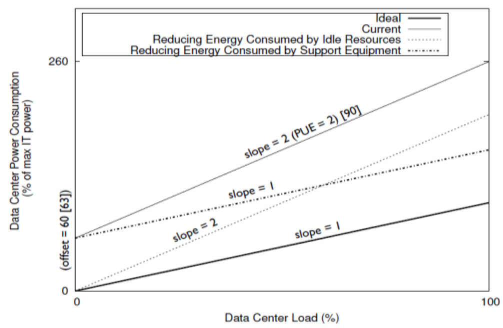

Fig 4. Schematic Diagram of Data Centre Power Consumption as a Function of Load. [1].

4. Kilowatt of Knowledge

Lesser Kilowatt means greener application. Increased enrolment rate translates into increase in data centres. This implies drawing more and more power from the grid for their servicing. This not only includes power to run the servers but also the energy costs involved in heating, ventilating, and air conditioning (HVAC), and lighting. A large data centre may require many megawatts of electricity, enough to power thousands of homes. Although not all the data centre servers are power intensive, those like search engines consume a lot of power [12].

4.1 Power of Learning

On average, online course is active for about 60 days from the date of enrolment and about 150 days from the date of completion. Also some courses are archived. For example, a student may utilize the online content for 3 hours/ day with live online sessions along with audio files, video files, e-papers, Tools and templates, quizzes. Also, some time is spent on revising, preparing assignments offline. Throughout this exercise monitors are in use. They are the most energy intensive component of a PC.

Consider the user end scenario for example. In a single student usage, on an average monitor uses 60 watts when fully on and 1 watt when switched off [15]. This translates to *216kJ/hour*. A 3 hour use = *648 kJ*. A 60 day course consumes *38880 kJ*. Expecting an average enrolment of 200 students per course, *7776 Mega Joules* of energy is consumed at user end. This translates to approximately *47 Giga Joules* of energy over the span of one year per course. Multiple enrolments to multiple courses are not considered here.

Energy consumption increase can be attributed to devices on the internet consuming large amounts of power. This is caused by great amount of traffic on the net coupled with sophisticated applications and users. One of them is the digital libraries hosted in the internet for shared access. Many universities and educational institutions host their books, journals, course materials, dissertations and research papers in the form of digital contents for access by millions around the world through internet. The sudden rise in social network usage such as Orkut, Facebook, personal blogs and web mails storage space are major sources of digital contents. The sources of digital content creations widened due to the modern devices (Table 1) and internet technologies such as web contents, emails, e-commerce information, online trading and much more [5].

Table 1. Sources of Information and Storage [5]

INFORMATION and STORAGE
Capturing/Creations
High end camera/Digital cameras, Camcorders/Camera phones/ web cam, Surveillance/Scanners. Multifunction peripherals, OCR/bar code reader Medical imaging, Digital TV & video, Graphic workstation, Digital voice capture, Landline telephone/VoIP, Mobile phone
Data Creations
PC Applications & Databases, Office applications, Email & Video teleconference , Chat/ IM/Smart phone/ PDA, Terminals/ ATM/Specialized PCs, Industrial machines/Home appliances, Production equipment/RFID/ sensors, Smart cards/ Video games, MP3 player/ IPod/SMS/MMS/GPS, Servers/Business firms/Application development
Data Storage
HDD, Optical , Tape , NV flash memory, IC, Laser disc

4.2 Energy Matters

An ideal data centre should consume zero energy under zero loads. The reality, however, is that in inadequately managed facilities, servers consume almost as much energy when idle or lightly loaded, as when heavily loaded [7]. At the service end, estimates put Google data centre power usage at 50 megawatts per data centre. At the end of a year, 432 million kilowatt-hours of energy is used per data centre [13]. There are approximately 500000 data centres worldwide. The LMS hosted with Moodle rooms at University of Montana required about 1380GB of storage to accommodate 2300 users [10]. This is a relatively low storage requirement considering the amount of storage available at data centres However, energy requirements at most data centres are provisioned for peak rather than average load and are very lightly loaded on average, considerably less than 50% typically [4].This estimate discounts the energy utilization by support infrastructure of a data centre like HVAC and lighting.

4.3 Energy Conservation

Measures to conserve energy in any way, however small can add significantly to ecology over a long run. The effort to save energy during data storage, transmission and usage has to be concertedly done by all participants in the transmission cycle. We suggest a few initiatives from either end to make a beginning towards conservation.

As discussed in section 4.1, monitors are indispensable for the learning process. Since they consume more energy during booting, they can be switched off until the boot is complete. Also, preference must be given to energy star computers over conventional computers. Measures to develop green applications by using smart algorithms to reduce active energy consumption cycles of the hardware must be promoted. Industry should insist not only energy star computers but also on energy star application. For this, standards need to be developed which result in a measurable performance of applications.

At the individual level, mechanisms to generate power through solar energy, wind energy or biogas must be encouraged to conserve energy. An online course is normally active for about 150 days after the course completion to enable revision and recapitulation by students. This causes load on the data centre. There is no data available regarding the frequency of utilization of this facility by students during this grace period. We have to assess the reduction in load on the data centre by reducing the activation period to 60 days.

5. Conclusion

In this paper, we have discussed the general power utilization for online learning course from the user end and from the data centre perspective. On the outset, though it may appear that e-Learning is adding into the carbon footprint, it may not really be the case. The CO_2 emissions caused during commuting between two locations, transportation, manufacture of traditional learning equipment like paper and pen, plastic components are definitely compensated for in WBL. As a future expansion of this work, we would like to make a comparative analysis of energy utilization by learners in a traditional environment and online environment. The issue of handling e-waste is yet to be focused on.

We would like to conclude that e-Learning has added to Green-IT by providing knowledge to many seekers at an affordable cost with limited damage to the environment. Also, SCORM based modules have reduced the development time of modules by increasing reusability and reducing the up-time for courses.

6. References

[1] Ganesh, L. Data Centre Energy Management. (Doctoral dissertation) Cornell University. http://www.cs.utexas.edu/~lakshmi/files/thesis.pdf. 2012.

[2] Hamilton, J. On Designing and Deploying Internet-Scale Services. In USENIX Large Installation Systems Administration (LISA). 2007.

[3] Greenpeace Report. How Dirty is Your Data? A Look at the Energy Choices that Power Cloud Computing www.greenpeace.org/international/en/publications/reports/How-dirtyis-your-data/. 2011.

[4] Kaplan, J., Forrest, W., and Kindler, N. Revolutionizing Data Centre Energy Efficiency. http://www.mckinsey.com/clientservice/bto/pointofview/pdf/RevolutionizingData_Centre_Efficiency.pdf. 2008.

[5] Mahalingam, P., Jayaprakash, N., Karthikeyan, S. Storage-Requirement Forecasting Analysis Model for Storage Area Networks. *International Journal for Computer Applications*. 19(6). 2011.

[6] Mc.Whorter, R.R. Evolution of Enabling Technologies for Green Computing -Scenario planning as the development of leadership capability and capacity; and virtual human resource development *(Doctoral dissertation). Texas A&M University.* 2011.

[7] Meisner, D., Gold, B. and Wenisch, T. *PowerNap: Eliminating Server Idle Power*. In ACM International Conference on Architectural Support for Programming Languages and Operating Systems (ASPLOS). 2009.

[8] Miller, R.: Who Has the Most Web Servers? Data Centre Knowledge. www.datacentreknowledge.com/archives/2009/05/14/whos-got-the-most-web-servers/.

[9] Murugesan, S. *Holistic view of Green IT- Harnessing Green IT Principles and Practices*. IT Pro, IEEE Computer Society. 2008.

[10] Online discussion thread. http://www.educause.edu/discuss/teaching-and-learning /instructional-technologies-constituent-group/moodlerooms-joule-administration

[11] Ramamoorthy, G., Tripathi, V. Forecast: “Forecast: Enterprise ICT Infrastructure Energy Consumption and Carbon Emissions, India, 2006-2015”. 2011.

[12] Somavat, P., Jadhav, S., Namboodiri, V. *Accounting for the Energy Consumption of Personal Computing Including Portable Devices* e-Energy ’10.Germany. 2010.

[13] www.energystar.gov/ia/partners/prod_development/downloads/EPA_Datacentre_Report_Congress_Final1.pdf

[14] Whitepaper. Greening of Business. T-Systems. Online: www.ictliteracy.info/rf.pdf/T-SystemsWhitePaper_Green-ICT.pdf

[15] www.swinburne.edu.au/ncs/swingreenoffice/resources/sustainable_office_equipment_brochure.pdf