Chapter 4
Green Computing: An Approach Toward Eco-friendly Environment

Kiranjit Kaur and Munish Saini

4.1 Introduction

Today's computing is based on the scenario where the consumer pays the provider only for when and how much they use the services mainly refers to as the "Pay-as-per-Use" model and such kind of model referred to as cloud computing [1]. Basically, cloud computing services are supported by servers (data center) where virtual machines are incorporated to provide isolation. The main problem with this data center is that their power consumption [3]. Cloud computing provides infrastructure, platform, and software as a service on demand [4]. The term green computing is used to lessen the problem of power consumption. It mainly focuses on the efficient usage of computing resources so that they cause a minimal impact on the environment. Mostly, IT departments consume an immense amount of power which leaves the carbon footprints in the atmosphere. Figure 4.1 measurement of energy consumption is being termed as "green computing." Green computing is practice for designing, manufacturing, using, and disposing of the computer server system in an effective way so that they do not cause a negative impact on the environment [2, 3].

So, we have to take some small initiatives just to have a big change. For instance, we should use Blackle instead of Google which will save a huge amount of energy. With this, we started some simple but effective initiatives like using sleep mode and standby mode in our PC or in mobile phones which will also save an immense amount of energy.

K. Kaur (✉) · M. Saini
Department of Computer Engineering and Technology, Guru Nanak Dev University(Asr), Amritsar, Punjab, India
e-mail: kiranjitkaur166@gmail.com; munish.cet@gndu.ac.in

J. S. Raj (ed.), *International Conference on Mobile Computing and Sustainable Informatics*, EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-030-49795-8_4

Fig. 4.1 Green computing [16]. (Source: green-computing-69791681, [16])

4.2 Need for Green Computing

Green computing is a technology that mainly focuses on designing a better computer system means their processing must be better and they must consume less energy. Nowadays, use of computer system and IT services has become a necessity for everyone, and it makes life easier and works rapidly which in turn saves time. The emission of a greenhouse gas like CO2 rises with an increase in power consumption. Since, the computer system and its peripherals also consume power even when these are idle. With this, data center also requires a large package of energy and cooling mechanism, but it leads to the wastage of energy at the time when the demand for power and cooling capacities are not fulfilled which in turn causes environmental pollution. Green computing mainly focuses on declining the energy utility level and reusability with the reduction of resource usage by means of sharing them. There are a number of steps that should be attained just to decrease the environmental threat which is caused by the overutilization of resources which increases the carbon dioxide concentration in the climate where we are just surviving, and these are just described as follow:

4.2.1 Cloud Computing

It has many benefits like it enables anybody to obtain environmental benefits of virtualization. It also remove the need for the user to run high power PCs since it provide infrastructure as a service.

4.2.2 Virtualization

It is one of the most important steps which can be attained just to overcome the problem of power consumption. It is the usage of more than one operating system on a single machine. The attainment of such a system can result in less usage of resources which can even increase the power efficiency and decrease the level of carbon dioxide in the environment.

4.2.3 Recyclability

Recycling of the waste or equipment is a one good deal toward reduction of environmental pollution [4].

- *Climatic Change*: Researches done in the passing years depicts that CO2 and emission of other substances have a drastic impact on the global climate and even though responsible for damaging our environment.
- *Cost Savings*: Green computing can lead to saving income at an amazing rate.
- *Power*: As the demands for energy get incremented, with the other hand, the supply for the same gets declines. So, not to face any problem regarding this, most of the industries are just generating their own electricity which will automatically force them to consume less power. And even the computing power consumption has reached a critical point [5].

4.3 Current Trends

Current trends are toward productive use of computing resources, and the most important resource is energy, and on the downside incrementation in the carbon content is considered as a major environmental threat. Therefore, the aim is just to reduce the vitality consumption and carbon content in the atmosphere and to escalate the overall computing performance. The following are various areas where the researchers are focusing to get the desired results. The areas are as follows:

4.3.1 Recycling of e-Waste

The greater part of the nation mainly those countries which are under development are in the need of some electronic companies which will manage the whole process of recycling for their items. Green computing must take the product life cycle into consideration just to reuse the items that have been produced. The survey provides a complete picture that shows that more than 130,000 PCs are disposed of on a

daily basis and even small percent of hardware is recycled at a time. Recycling of the e-waste is an easy job that can be made under consideration. The reusability of lead and mercury helps to maintain dignity as it reduces the bad impact on the environment just by saving the energy [6].

4.3.2 Data Center

The data center of green computing is getting a great concern nowadays as they are known for their inefficient vitality utilization. As viewed from the survey of the US Department of Energy in 2006, it was experienced that the data center consumed one-fourth of electricity and even the demand for electricity rises respectively. As, the demand increases, the cost of the electricity also gets increased with nearly about $7 billion per year. The flow report undertaken by the department of energy in 2011 indicated that the data center consumed about 4% of all the US electricity and this utilization of energy gets doubled after 4 years which was reported in 2015 [7]. Just focusing on the more demand for energy utilization in the data center, much concern is on the following [8]:

- Information System – For building a green data center, the perfect design of data frameworks for business requirements is a key function. According to the green computing, the efficient servers, the storage devices, networking equipment, and selection of power supply, all these are assumed as a key job in the planning of information systems.
- Cooling System – It is suggested by the researchers that at the underlying phase of constructing the data center cooling system, the current and upcoming requirements are to be considered and design the cooling system framework in such a way that it is expandable according to the requirements.
- While designing and selection of data center electronic system equipment, all the initial and the future burdens are to be considered.

4.3.3 Energy Utilization

Various researchers think that a source and amount of energy utilization gives rise to the emissions of greenhouse gas. Due to which various organizations are using the upcoming condition:

Reduction in energy utilization = reduction in emission of greenhouse gas = reduction in operative costs of a data center.

It demonstrates that undertaking lesser and number of energy-efficient frameworks while just refactoring the application environments to utilize physical resources is the best structural model. As per Environmental Protection Agency,

around 35% to 45% of PCs are kept "ON" after office hours and during the end of the week and even around 80% of those PCs are idle.

4.3.4 Virtualization of Resources

The meaning of virtualization is described by its name "virtualization" that is the abstraction of computer resources. It is the main aspect of green computing. In virtualization, the two or more logical computer systems are just running on a single physical hardware. Virtualization is a pattern of green computing as it offers both virtualization and management software for the virtualized environment [9]. One of the ideal approach towards green and spare enough space, enough resources, and the environment is by streamlining efficiency with virtualization. This type of green computing gives rise to server consolidation and just increases the security of computer [10]. Virtualization permits usage of computer resources and advantages as follows:

- Lesser the number of the hardware
- Power off the servers which are not in use at a time just to spare the energy
- Reduction in all-out space leads to cost savings

4.4 Related Work

4.4.1 Power Aware Hybrid Deployment

To cope with the difficulties such as trade out of energy consumption and QOS, various efforts in the conscious QOS and implementation capabilities of applications based on the work investigator called Zhiwu, Fanfu, and the other researcher Zhengwei have proposed an intensive hybrid implementation of I/O and CPU in order to optimize resource utilization in the virtualization environment. In this study, they investigated the resource allocation between virtual machines where I/O and CPU-oriented applications take place, in order to run the hybrid implementation of applications that require energy. To bring out the I/O difficulties and the CPU resource in the virtualization environment, the researchers used Xen as the virtual machine monitoring for the experimentation. They also conclude that the CPU-Intensive applications in the hybrid deployment applications need to satisfy Quality of service [11].

- *Power and Its Utilization*: Power consumption is demonstrated as a percentage value of peak power across the various data centers.

The estimation for the power usage was proposed in the model of Wang [12] for a fixed operational frequency, and it was concluded that power utilization of server

is just approximately the static functions of the server utilization that is the number of servers used. As a result, they conclude from the analysis that CPU-Intensive and I/O-Intensive applications hybrid deployment can improve power efficiency.

4.4.2 Green Algorithm for Power Management

In the research work of R. Yamini in 2012, it was proposed that due to the increase in the global warming trend, the large amount of the carbon content is just taking place in the environment which in return becomes the major challenge for the environment. Just to overcome the problem of the energy crisis, green computing just join hands to make the environment green and saver. But, green computing needs a number of algorithms and redesigning of the mechanism to increase energy efficiency. There are a number of approaches to green computing which include virtualization, data center, recycling of e-waste, utilization of resources, power management, and so on. The basic principles of cloud computing is to make the computing be assigned in great number of distributed computer or remote server. Currently, a large number of cloud computing systems waste a tremendous amount of energy and emit a considerable amount of carbon dioxide. The carbon footprints harm the environment as a large amount of carbon dioxide content causes pollution. So, it becomes a necessity to reduce pollution and also increment the energy efficiency level. R. Yamini uses the green algorithm to increase the energy efficiency. Both public and private clouds are used for analysis purposes. Cloud computing with green algorithm can enable more energy-efficient use of computing power, as energy efficiency is inversely proportional to resource utilization. In this study, the task was to make a streamline for resource usage which in return improves energy efficiency. Based on the above fact that resource utilization is related to energy efficiency, Malviya has successfully developed two energy-conscious task consolidation heuristic. Hence, the outcome in this study should not only focus on the electricity bill reduction of the infrastructure provider of cloud but also depict the possible operational cost savings just by overcoming the impact on the environment [13].

4.4.3 Power and Energy Management for Server System

The researcher Ricardo and Ram Rajamony works on power and data center efficiency. The study was proposed in 2009 using the power and energy consumption as a technique for the data center. These data center controls thousands of servers, and the cooling mechanism was supported. The main effort was to conserve energy in the servers. Inspired by this initial progress, researches just go deeper into this topic [14].

4.5 Comparison Table

Name of author	Year	Technique used	Power efficiency	Data center efficiency	Resource utilization	Cost saving
Zhiwu Liuma	2010	Power-aware hybrid deployment	Yes	No	Yes	No
Fanfu Zhou	2011	Power-aware hybrid deployment	Yes	No	Yes	No
Zheng	2010	Power aware hybrid deployment	Yes	No	Yes	No
R. Yamini	2012	Green algorithm	Yes	No	No	Yes
Richardo Binachni	2009	Power and energy management for server system	Yes	Yes	No	No

4.6 Conclusion

Green computing is not only helping companies to reduce cost but even also saves the environment and makes it sustainable. As with the span of time, they need for computers as a dependable machine increasing progressively. To overcome the workload on a single system, more systems are to be preferred. But as well said by David Wang "Every single step consumes energy and buying a new, more efficient computer may not always be the right answer" [15]. So, a focus should be made on resource utilization and implementing more green techniques in our future.

References

1. S. Saha, A. Mitra, Towards exploration of green computing in energy efficient optimized algorithm for uses in fog computing, in *In International Conference on Intelligent Computing and Communication Technologies*, (Springer, Singapore, 2019), pp. 628–636
2. D. Yao, C. Yu, H. Jin, J. Zhou, Energy efficient task scheduling in mobile cloud computing, in *In IFIP International Conference on Network and Parallel Computing*, (Springer, Berlin, Heidelberg, 2013), pp. 344–355

3. Z. Liu, R. Ma, F. Zhou, Y. Yang, Z. Qi, H. Guan, Power-aware I/O-intensive and CPU-intensive applications hybrid deployment within virtualization environments. In 2010 IEEE international conference on Progress in informatics and computing. IEEE **1**, 509–513 (2010)
4. R. Sharma, Approaches for green computing. International Journal of Innovative Computer Science & Engineering **2**(3) (2015)
5. P. Carinhas, *Green Computing Guide* (Texas, Fortuitous Technologies, 2009)
6. Harmon, R. R., Demirkan, H.: The corporate sustainability dimensions of service-oriented information technology. In 2011 Annual SRII Global Conference. IEEE, pp. 601–614 (2011)
7. P. Kurp, Green computing. Commun. ACM **51**(10), 11–13 (2008)
8. O. VanGeet, Best practices guide for energy-efficient data center design (No. DOE/GO-102010-2956), in *EERE Publication and Product Library*, (2010)
9. A. Anju, Security issues in green computing. Int. J. Adv. Res. Comput. Sci. **8**(4) (2017)
10. H.Y. Jeong, Y.S. Jeong, J.H. Park, G-cloud monitor: A cloud monitoring system for factory automation for sustainable green computing. Sustainability **6**(12), 8510–8521 (2014)
11. D. Ongaro, A.L. Cox, S. Rixner, Scheduling I/O in virtual machine monitors, in *Proceedings of the Fourth ACM SIGPLAN/SIGOPS International Conference on Virtual Execution Environments*, (2008), pp. 1–10
12. Z. Wang, X. Zhu, C. McCarthy, P. Ranganathan, V. Talwar, Feedback control algorithms for power management of servers. In Third International Workshop on Feedback Control Implementation and Design in Computing Systems and Networks. (2008)
13. R.A. Sheikh, U.A. Lanjewar, Green computing-embrace a secure future. International Journal of Computer Applications **10**(4), 22–26 (2010)
14. R. Bianchini, R. Rajamony, Power and energy management for server systems. Computer **37**(11), 68–76 (2004)
15. A. Hooper, Green computing. Communication of the ACM **51**(10), 11–13 (2008)
16. https://www.slideshare.net/sravaniponnuru/green-computing-69791681