International Journal of Applied Engineering & Technology

DESIGN, IMPLEMENTATION, AND ANALYSIS OF AN EFFICIENT APPROACH FOR OPTIMIZING DATA CENTER ENERGY CONSUMPTION

Krishna Prasad R[1] and Dr. Manoj Eknath Patil[2]
Research Scholar[1] and Research Guide[2]
[1,2]Department of Computer Science & Engineering,
[1,2]Dr.A.P.J.Abdul Kalam University,Indore (M.P)
k.p23020@gmail.com[1] and mepatil@gmail.com[2]

ABSTRACT
Due to the nature of big data, the volume and quantity of data that must be stored and processed in hyperscale data centers (HDCs) increase as their usage grows. Before initiating an HDC project, a detailed financial analysis of the energy requirements and potential energy costs is essential. We propose a framework based on Power Usage Effectiveness (PUE) to estimate future global energy demands. This framework considers all possible sources of heat and electrical load. It employs both a physical model and a statistical framework to forecast the energy consumption of IT equipment and the data center. Additionally, the framework includes methods to calculate the carbon emissions and electricity costs associated with the data center. To determine the annual PUE for sixty regions, we utilized hourly weather data as climate factors alongside a limited set of energy attributes. For instance, we examined the Carbon Usage Effectiveness (CUE) and electricity prices in India. Real-time data and experiments demonstrate that our approach can accurately predict the total energy consumption of HDCs. This capability enables comprehensive HDC feasibility studies and addresses a significant research gap in the Asia-Pacific region.

Keywords: Hyperscale Data Centres , Power Use Effectiveness , Carbon Usage Effectiveness , Data Centre.

I. INTRODUCTION

People are mostly to blame for the changes in global emissions that have been measured. Global warming happens when the average temperature of the Earth's surface rises above the average temperature of the atmosphere. The release of greenhouse gases into the atmosphere is a big reason why people are contributing to global warming. There are many different types of greenhouse gases, like carbon dioxide, ozone, nitrous oxides, and methane. Factories, the way we get rid of animal waste, and the use of data centres are all big contributors to greenhouse gas emissions. Data centres, which are part of the IT industry and account for about 2% of global emissions, release almost all of the carbon dioxide (CO_2) into the air. "Green computing" refers to the current trend in many fields to use and make computer equipment in ways that are better for the environment. A technique called "green computing" is being used to cut down on the amount of energy that data centres use. As part of "green computing," data centre infrastructure should be set up to use as few resources as possible.

Some of the technologies that need cooling to be built are computers, backup power systems, network gear, and storage that is good for the environment. Energy use has gone up because of the huge amount of data that needs to be managed. Estimates show that nearly 500 large data centres use almost 3% of the world's energy. Many these centres are also in western Europe and eastern Asia, in addition to the United States. Big data includes the fact that more and more data is being made and stored in the cloud, which is also growing quickly because of many technological advances. Service providers change their goods and services to meet their customers' needs.

II. RELATED WORK

Panwar et al.(2022) The goal of this literature review is to make a list of the studies that have been done on energy consumption (EC) using heuristics, metaheuristics, and statistical methods from the field of machine learning. To manage the resources and make the best use of energy, a number of tasks have been done, such as predicting host CPU consumption, finding underload and overload, choosing migration and placement of virtual machines, and so on. This review compares and contrasts how well different ways of cutting energy use work. Researchers have tried many different ways to cut down on SLAVs and energy use in cloud data centres.

Hingamire et al.(2019) We suggest that you use a cloud data centre. I am in charge of running an operation on our cloud data centre and figuring out how much energy it will use. We use an algorithm that takes energy into account to figure out how much power is needed. Lastly, we look at how much energy is saved when the task is done in the cloud instead of on a local machine. The suggested system is shown to work better than the current system by comparing them.

Philippe Roose et al.(2018) In this analysis, we looked at how different kinds of Cloud system administrators affect the amount of energy used in the Cloud as a whole. With the help of this research, new models of how people use energy will be made and proposed. The goal is to make energy forecasts more accurate and precise. The energy consumption models can be used to help cut down on the amount of energy used. Both of these scientists are interested in finding ways to control how much energy is used.

Hui LIU et al.(2017) In this study, we suggest using a model that is both static and doesn't change over time (AEC). Cross-degree and reuse-degree are two quantitative measurements that the model suggests adding to the code structure. It also sets up a link between EC and the measurements. Even though AEC doesn't give a precise measurement of EC, it can still show EC, check the effect of optimization, and compare ECs to those of other jobs.

Rong, et al.(2016) This article is about how to design, build, and run a data centre in a way that saves energy. The use of renewable energy sources, energy-saving technologies for server rooms, and high-performance computing are some of the things that are talked about. Here, we give a full list of suggestions for how to improve the performance of data centres while reducing their impact on the environment. Energy efficiency, saving money, and protecting the environment are just a few of the many things that these plans take into account. This paper also talks about new ways to make data centres use less energy.

III. METHODOLOGY

In this part of the article, we look at how the design of a system can make it easier for data centres to use power from renewable sources while also reducing their energy footprint. This is a model that includes a lot of data centres. The study looks at a model with data centres in different parts of the world. One or more of the places that a proposed is in charge of. Each data centre can get electricity from the grid as well as from renewable energy sources that have batteries that can store electricity. Each data centre has its own system for keeping a steady flow of electricity from batteries. Workload is made by user areas, which then send it to the load scheduler so it can be spread out. It is expected that the scheduler knows how much renewable energy is available in each of the data centres. The amount of electricity used by the jobs is equal to the amount of work that needs to be done. The load scheduler will decide which data centre will handle the work based on the environmentally friendly policy that was set. Scheduling is based on how much work needs to be done (the demand for electricity) and how easy it is to get to renewable energy sources. So, there are two ways to distribute work: one is environmentally friendly, and the other saves energy. Once these assumptions have been made, it is possible to build the framework. There is a limit to how much renewable energy can be used, and that limit is tied to a certain amount of time. After a set amount of time, the amount of clean energy stored in the battery will be brought back up to its full capacity. When looking for a data centre to house your activities, you should choose the first one that meets your needs in terms of using renewable energy sources.

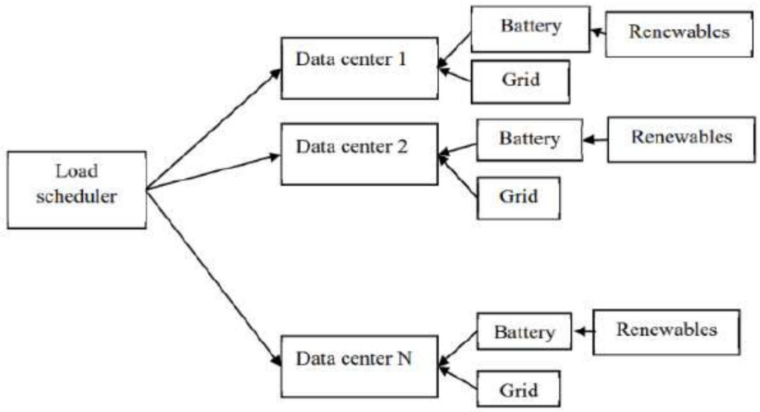

Figure 1: System model

It is assumed that jobs will be sent to the data centre with the lowest index, where they will be given to the available resources and processed without any problems. It was shown that there is an urgent need to make cloud-based and Internet of Things (IoT) programmes much more energy efficient. But when it comes to Cloud IoT, the situation gets even more complicated because new dimensions are added (such as energy efficiency, resource allocation, and so on). The proposed method tries to solve the problem by using a genetic algorithm to find the best placement and choice of behaviour while the task is being done. The main reason for all of these efforts is to save energy, which is the most important reason of all.

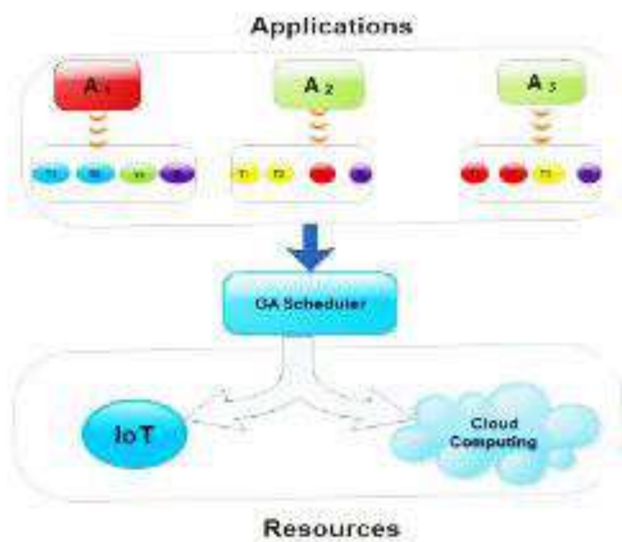

Figure 2: Getting the most out of the power that Cloud IoT uses has been suggested as a way to save money.

At first, it is thought that a lot of energy is needed to do a lot of different jobs that are all different sizes. Since something is likely to happen, it is assumed that it will. So, we're going to break each app into smaller tasks and then figure out how to get the whole thing running on the Cloud IoT. Thanks to the Internet of Things (IoT) or cloud computing, everything gets done. But the answer to the question of which architecture to use will depend on how long it takes to do the same task in the IoT and how long it takes to send the message. Add up the times it takes for data to go from the IoT to the cloud and back again. This is the total transmission time. Using this method, the runtime of any cloud-based IoT task can be calculated using the same inputs as any other cloud-based IoT task. Then, we figure out how much power both the Internet of Things and the cloud used, and we use our best guess of how much power was used during the instruction to extrapolate the cloud IoT number. Using the mathematical model, the following formula is used to figure out how long it will take to finish the job (ATij), as shown in Equation (1). Where Ns is the processing speed of the IoT and Dij is the amount of data that the ATij task needs.

$$ET\left(AT_{ij}\right)_{IoT} = \frac{D_{ij}}{N_s}$$

How Much Power IoT Devices use

IoT nodes do work; PIoT is the amount of power used by IoT; G is the cloud-to-node channel gain; and Ptran is the amount of power needed to send a task (ATij). You can figure out how much energy the Internet of Things uses by adding up how much energy it takes to process (Eproc) and send (Etrans) (Etran). An equation can be used to describe it (2).

$$E_{IoT} = E_{proc} + E_{tran}$$

One half of the proposed method looks at the energy used by IoT, and the other half looks at the energy used by the cloud. Algorithm 1 figures out how much energy each task will take and then uses GA to improve itself. Input factors for GA include the tasks that are being asked for, the amount of data for each task, the processing speed in IoT, and the rate at which data is transferred. The output is the best use of energy that can be made. The suggested method can be used to judge the quality of execution whether the processing is happening on an IoT node or in the cloud. If the time it takes to do the work at the IoT node is less than the time it takes for the network to respond, the work will be done locally. If not, it will be sent to the cloud.

In the Internet of Things, Method 1 of the Algorithm call sequence is in charge of estimating how much power is used. Several things go into the first step, such as how much energy IoT devices use, how much transmission power is needed, and how much gain the channel has. Line 2 of Procedure 1 is used to figure out both the processing energy consumption (or Eproc) and the transmission energy consumption (Etran). Line 3 of Procedure out how much energy the Internet of Things uses as a whole for all the things that happen on local devices.

IV. RESULTS ANALYSIS

The CloudSim toolkit is utilised in order to conduct the effectiveness analysis of the method. CloudSim allows users to model any data centre, host, computational resource, virtual machine, application, user, or management policy. CloudSim also allows users to simulate cloud computing environments. In addition to this, CloudSim is compatible with a wide range of additional modelling situations that are associated with clouds. In the course of the proposed research, an approach to job distribution will be developed and examined that takes into account environmental factors while maintaining a responsible stance.

Through the use of simulation testing, it was possible to ascertain whether or not the proposed algorithms and proposed algorithms were effective. As part of the case study's concentration on a global CSP, ten data centres that are beneficial to the environment were utilised. The workload scheduler is responsible for processing jobs that have been sent in from all around the world. Based on the scheduling strategy, the proposed algorithms selects a data centre powered by renewable energy and a server that are capable of managing the workload while operating at or near their maximum capacity. If you want this technique to work, you have to make sure both of these conditions are met first. The proposed algorithms algorithm chooses the first-fit technique, which gives precedence to operating data centres with quick access to copious renewable energy sources, in order to achieve the highest possible level of efficiency. This is the method that is utilised to load tasks onto servers. The first-fit approach is the name given to this method of operation. There is a possibility that the dependability and accessibility of renewable energy that is generated locally would be unpredictable. In order to take into account a large number of different renewable energy sources, the simulation makes use of estimates derived from real-time.

Table 1: Simulation Parameters

Parameter	Value
Cloudlet length	200-100 MI
No. of Datacenters	15
Types of Servers	Heterogeneous
No. of VMs	50

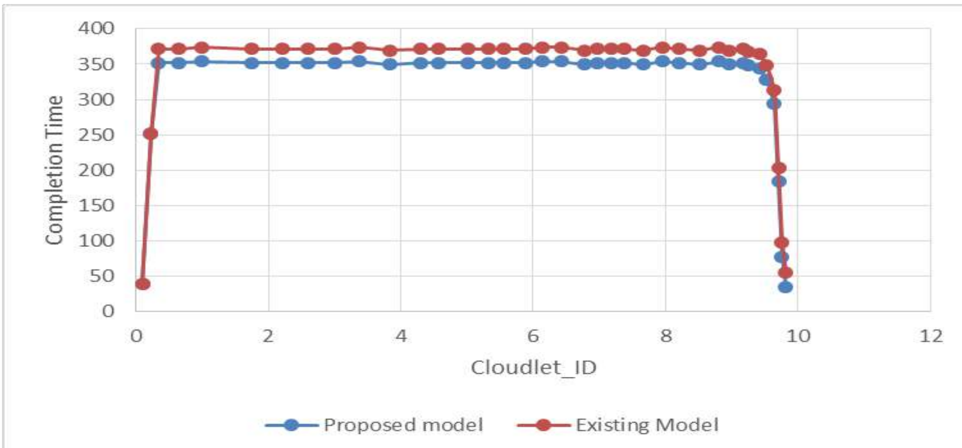

Figure 3: Comparative Analysis proposed approach and existing approach

New solution to load balancing, updating the algorithm previously developed. The proposed approach represents an optimization algorithm. The proposed optimization algorithm selects the right VM depending on the selection possibilities and the health criteria, and hence the proposed load balancing device executes a redistribution of the task. The proposed algorithm requires two meta-heuristic algorithms and fractional theory, rendering the selection process highly competent. The work is carried out in three cloud configurations and the results are calculated by means of metrics such as load and number of tasks. The output analysis states that the approach proposed has improved performance in diverse scenarios and may therefore be suitable for load balancing, as the load and the number of tasks reset for complex cloud setups are limited.

V. CONCLUSION

Even though a lot of progress has been made in the last few decades toward more efficient ways to control how much energy communication networks use, this task is still hard. This article talks about the Cloud IoT system, which is based on a genetic algorithm (GA) that was made to save energy. The GA was made using the python framework, and this framework was then added to the simulation model. The simulation tests how well the proposed method works by simulating different situations, such as genetic algorithm operators (crossover, mutation, and generation number). After that, a detailed simulation is run to show that the mechanism works better than the proposed method. We look at data from simulations to see if the best settings for the suggested strategy lead to the results we want.

REFERENCE

1. Panwar, S.S., Rauthan, M.M.S. & Barthwal, V. A systematic review on effective energy utilization management strategies in cloud data centers. J Cloud Comp 11, 95 (2022). https://doi.org/10.1186/s13677-022-00368-5

2. Hingamire, Manjushree, and Ramkrishna Vadali. “Energy Consumption Estimation Framework at Source Level for Data Centers.” SSRN Electronic Journal, 2019, 10.2139/ssrn.3419260.

3. Philippe Roose, Merzoug Soltane, Derdour Makhlouf, Kazar Okba. PREDICTIONS & MODELINGENERGY CONSUMPTION FOR IT DATA CENTER INFRASTRUCTURE. Advances in Intelligent,Systems and Computing, 2018, Tanger, Morocco. pp.1-11. ffhal-02437210.

4. Hui LIU, Fusheng YAN+, Shaokui ZHANG, Tao XIAO, Jie SONG. Source-Level Energy Consumption Estimation for Cloud Computing Tasks,November 2017IEEE Access PP(99):1-1DOI:10.1109/ACCESS.2017.2778309.

5. Rong, Huigui & Zhang, Haomin & Xiao, Sheng & Li, Canbing & Hu, Chunhua, 2016. "Optimizing energy consumption for data centers," Renewable and Sustainable Energy Reviews, Elsevier, vol. 58(C), pages 674-691.

6. Sanjeevi, P., and P. Viswanathan. “NUTS Scheduling Approach for Cloud Data Centers to Optimize Energy Consumption.” Computing, vol. 99, no. 12, 25 May 2017, pp. 1179–1205, 10.1007/s00607-017-0559-4.

7. Diouani, Sara, and Hicham Medromi. “An Adaptive Autonomic Framework for Optimizing Energy Consumption in the Cloud Data Centers.” International Journal of Intelligent Engineering and Systems, vol. 12, no. 4, 31 Aug. 2019, pp. 111–129, 10.22266/ijies2019.0831.12.

8. Singh Gill, Jaspreet, and Geet Kiran Kaur. “Optimizing the Energy Efficiency of the Modern Data Centers Using Ant Colony Optimization.” Indian Journal of Science and Technology, vol. 9, no. S1, 30 Dec. 2016, 10.17485/ijst/2016/v9is1/103143.

9. Ghodousian, Amin, and Maryam Raeisian Parvari. “An Integer-Linear Algorithm for Optimizing Energy Efficiency in Data Centers.” International Journal in Foundations of Computer Science & Technology, vol. 6, no. 4, 30 July 2016, pp. 01-18, 10.5121/ijfcst.2016.6401.

10. Martín-Chivelet, Nuria, and David Montero-Gómez. “Optimizing Photovoltaic Self-Consumption in Office Buildings.” Energy and Buildings, vol. 150, Sept. 2017, pp. 71–80, 10.1016/j.enbuild.2017.05.073.

11. Chang, Kyungmee, et al. “Optimizing Energy Consumption for a Performance-Aware Cloud Data Center in the Public Sector.” Sustainable Computing: Informatics and Systems, vol. 20, Dec. 2018, pp. 34–45, 10.1016/j.suscom.2018.10.003.

12. Shrimali, Rahul, et al. “Proposed Caching Scheme for Optimizing Trade-off between Freshness and Energy Consumption in Name Data Networking Based IoT.” Advances in Internet of Things, vol. 07, no. 02, 2017, pp. 11–24, 10.4236/ait.2017.72002.

13. Jalali, Fatemeh, et al. “Energy Consumption of Content Distribution from Nano Data Centers versus Centralized Data Centers.” ACM SIGMETRICS Performance Evaluation Review, vol. 42, no. 3, 8 Dec. 2014, pp. 49–54, 10.1145/2695533.2695555.

14. Uchechukwu, Awada, et al. “Retraction Note: Sustainable Cost and Energy Consumption Analysis for Cloud Data Centers.” Frontiers of Computer Science, vol. 14, no. 1, 24 Oct. 2014, pp. 239–239, 10.1007/s11704-015-4020-6.

15. Tarahomi, Mehran, and Mohammad Izadi. “A Hybrid Algorithm to Reduce Energy Consumption Management in Cloud Data Centers.” International Journal of Electrical and Computer Engineering (IJECE), vol. 9, no. 1, 1 Feb. 2019, p. 554, 10.11591/ijece.v9i1.pp554-561.

16. Y. Ran, H. Hu, Y. Wen and X. Zhou, "Optimizing Energy Efficiency for Data Center Via Parameterized Deep Reinforcement Learning," in IEEE Transactions on Services Computing, 2022, doi: 10.1109/TSC.2022.3184835.

17. Katal, A., Dahiya, S. & Choudhury, T. Energy efficiency in cloud computing data centers: a survey on software technologies. Cluster Comput (2022). https://doi.org/10.1007/s10586-022-03713-0

18. Al Ridhawi I, Kotb Y, Aloqaily M, Jararweh Y, Baker T. A profitable and energy-efficient cooperative fog solution for IoT services. IEEE Trans Indust Inform. (2019) 16:3578–86. doi: 10.1109/TII.2019.2922699.

19. Dayarathna, M.; Wen, Y.; Fan, R. Data Center Energy Consumption Modeling: A survey. IEEE Commun. Surv. Tutor. 2016, 18, 732–794.

20. Chi, C.; Ji, K.; Marahatta, A.; Song, P.; Zhang, F.; Liu, Z. Jointly optimizing the IT and cooling systems for data center energy efficiency based on multi-agent deep reinforcement learning. In Proceedings of the Eleventh ACM International Conference on Future Energy Systems, Melbourne, QC, Australia, 22–26 June 2020; pp. 489–495.