A Systematic Mapping Study on Green Load Balancing Algorithms for Cloud Data Centers

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***Abstract*—This paper analyses green cloud computing with a focus on workload distribution, resource allocation, and sustainable load balancing to increase energy efficiency in cloud data centers. Our systematic mapping study examines current research to identify progress and challenges in developing energy-efficient solutions, given the growing energy demands of cloud services. Using a methodical approach, we reviewed 23 papers, classifying them according to their contribution types , research types, and focus areas. Important conclusions show that although a lot of work has gone into developing theoretical frameworks and algorithms to cut down on energy use, problems still exist with resource allocation and performance maintenance in dynamic cloud environments. The study additionally highlights research gaps, especially in flexible resource allocation methods and real-time load balancing. Contributions to research were shared through significant platforms such as IEEE and Scopus. Our results highlight the necessity of further research into green computing techniques in order to reduce the environmental effect of cloud data centers without affecting dependability or performance. The goal of this research is to guide future studies into developing cloud computing methods that are more sustainable and efficient.**

***Keywords*—green cloud computing, load balancing, energy efficiency, cloud data centers, sustainability.**

I. Introduction

The rapid expansion of cloud computing has revolutionized the way data is stored, processed, and accessed, with cloud data centers at the core, housing vast arrays of servers and networking equipment. However, this advancement comes with significant energy consumption, heightened by the growing amount of data generated and processed globally due to fields such as Big Data, the Internet of Things (IoT), and Cloud Computing. To address the rising operational costs and environmental impact, green computing and sustainable practices have emerged as critical areas of research, focusing on enhancing energy efficiency through optimized load balancing, workload distribution, and resource allocation [1], [2]. However, while these strategies can reduce energy usage and maintain performance, special attention must be given to time-critical applications hosted in the cloud, as changes to data allocation or load balancing must not compromise the system's reliability or real-time capabilities [3].

Environmental sustainability is one of the most pressing global challenges today, driving our decision to conduct research on green cloud computing. As cloud computing continues to grow, its energy consumption rises as well, making it essential to explore sustainable methods for managing cloud data centers [4]. By focusing on techniques like load balancing, workload distribution, and resource allocation, our research aims to identify ways to optimize energy usage. Our interest in this subject stems from its potential to not only enhance the efficiency of cloud operations but also align technological innovation with environmental responsibility. The goal of our study is to systematically examine the current methods and future opportunities to improve the energy efficiency and sustainability of cloud computing, ensuring that data centers can operate in a way that minimizes their ecological footprint while maintaining high performance.

The rest of the study is structured as follows: The process for our systematic mapping study is outlined in Section 2, along with the screening techniques, classification scheme, and preliminary search findings. We go into great detail about our findings and analysis from the mapping study results in Section 3. The discussion is provided in Section 4. The paper's conclusion and future research directions are provided in Section 5.

II. The mapping process

A systematic mapping study aims at providing a deep overview of research conducted in a particular field and is also directed towards structuring the research results in an efficient manner to identify research gaps [24]. In order to perform a systematic mapping study on “Real-time cloud services” , we have followed an approach detailed by Petersen et.al [24]. The study approach is divided into 5 steps:

Figure 1: Mapping process [24]

A. DEFINITION OF THE RESEARCH

RQ1: Which topics related to green (sustainable) load balancing algorithms in cloud data centers have been investigated, and to what extent?

Motivation: This question aims to identify the primary subjects and aspects that have been studied in the area of sustainable load balancing in cloud data centers, highlighting any gaps in understanding or areas of particular focus.

RQ2: What types of research methods and contributions have been made in the study of green load balancing algorithms for cloud data centers, and to what extent has each type been represented?

Motivation: The purpose of this question is to evaluate the depth and breadth of research in the topic by looking at the various study methodologies (such as theoretical, empirical, and simulation-based) and understanding a variety of contributions (e.g. as new algorithms, evaluations, and surveys).

RQ3: In which forums has research on green (sustainable) load balancing algorithms for cloud data centers been published?

Motivation: This question seeks to identify the principal publication platforms (conferences, journals) where research on this issue is distributed, thus providing information about where the field's key contributions are published.

B. Conducting the search of relevant papers

Before beginning the search for our study on Green Load Balancing Algorithms for Cloud Data Centers, we prepared a set of keywords that are essential to our area of study. The purpose of these keywords was to identify publications that addressed sustainable and green approaches to load balancing in cloud data centers. The search terms were specifically designed to find articles that highlight energy efficiency and sustainability in cloud computing systems while discussing load balancing algorithms and approaches in this field.

We limited the databases used for this study to IEEE Xplore and Scopus, which are known for their substantial peer-reviewed content and focus on technical and scientific research. The keywords that best represent our field of research have been integrated into the carefully structured search searches. We specifically reviewed papers that addressed load balancing and green/sustainable computing in relation to cloud data centers.

The search query used in our study was: (”green” OR ”sustainable” OR ”energy efficiency”) AND (”load balancing” OR ”workload distribution” OR ”resource allocation”) AND (”cloud data centers” OR ”cloud computing” OR ”data centers”). This query was applied across two selected databases, covering the years 2022 to 2024. From IEEE Xplore, a total of 420 articles were obtained from IEEE Xplore, while 595 articles were obtained from Scopus. This resulted in an initial pool of 1,015 articles. To refine these results and focus on the core areas of green/sustainable load balancing in cloud data centers, we implemented a multi-phase screening process.

C. Paper screening

To effectively select the most relevant papers in the area of our study, a screening process is required. Our study's screening process depends on a number of inclusion-exclusion criteria. The following provides a detailed explanation of our inclusion-exclusion criteria.

Inclusion Criteria

1) Papers included only peer-reviewed articles, conferences, and journals.
2) Papers should be based on green/sustainable cloud computing.
3) Papers must address the cloud from “cloud computing” and “cloud services” perspectives.

4) Papers were selected in a timespan range of 2022-2024.

Exclusion Criteria

1) Studies that focus on cloud computing aspects unrelated to sustainability will be excluded.
2) All the non peer-reviewed papers in the form of abstracts, editorials, or keynotes are excluded.
3) Papers which are not in the English language are excluded.

The inclusion-exclusion criteria that we defined could effectively filter out papers that were not relevant to the current study. The four stages of the screening process, which was based on the inclusion-exclusion criteria mentioned above, include keyword, title, abstract, and full text screenings.

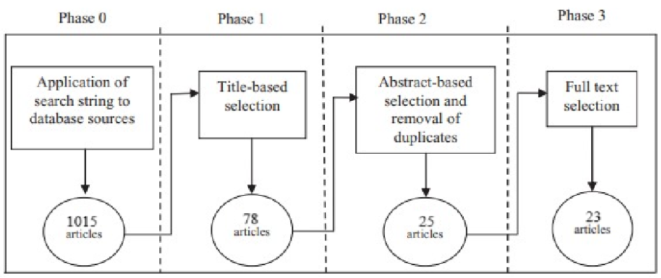

Figure 2: Selection Process

The paper selection followed a four-phase process as shown in Figure 1:Phase 0: In this phase, we have screened the papers based on the application of our search string to various database sources. The results of Phase 0 were obtained and it yielded us with a total of 1015 articles from different database sources.

Phase 1: In Phase 1, we consider all the papers from Phase 0 and do a 'Title-based selection' and this could efficiently bring down the paper results when compared to Phase 0. By performing a title based search query, we could bring down the papers to 78 of which IEEE and Scopus constitute 41 and 37 articles, respectively.

Phase 2: After screening the papers based on title, we proceeded to Phase 2, which is an abstract based selection. In this phase, we eliminated the duplicate papers and thus could bring down the paper count to 25 articles, of which IEEE has a contribution of 16 and Scopus 9 articles.

Phase 3: In some of the papers, reading the abstract was not enough to gather the necessary information therefore we continued by reading the full-text, mainly the introduction and conclusion sections. This could further narrow our search to 23 papers, which we consider further for our mapping study.

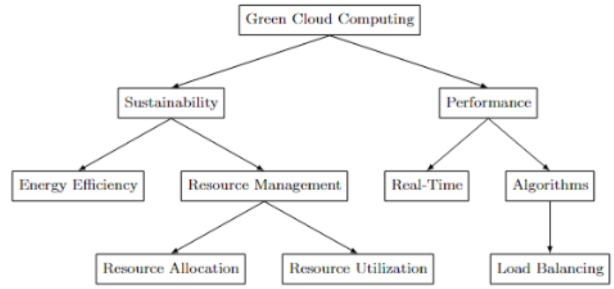

Figure 3: Classification Scheme

DataBases	Initial	Title	Abstract	Full Text
IEEE	420	41	16	14
Scopus	595	37	9	9
Total	1015	78	25	23

Table I: Database Search Results

D. *Abstract keywording*

The next stage of our mapping study was to assign each paper a relevant set of ”keywords”. Our main goal was to find articles about green/sustainable methods and algorithms built for optimizing load balancing, resource allocation, and energy efficiency in cloud data centers based on the previously established research objectives. At the same time, we aimed to look at the difficulties in achieving efficient and consistent performance in cloud environments.

The primary keywords we assigned were: 'energy-efficient techniques', 'load balancing algorithms', 'resource allocation strategies', 'sustainable cloud computing', and 'real-time performance challenges'. After analyzing the content and focus of the selected papers, we developed a more detailed classification scheme that reflects the higher-level view of the research field in this topic.

We divided the articles on green load balancing strategies into three main categories: performance, resource management, and energy efficiency. We were able to break down the research into separate categories, each of which covered an essential part of sustainable load balancing in cloud data centers.

Papers in the Energy-efficient category mostly addressed approaches to reducing cloud data center energy usage. These approaches included cost-aware energy models, power-aware methods, and other techniques meant to reduce energy use without losing system functionality.

The papers were separated into discussions on resource allocation and resource utilization under the Resource Management Strategies category. Heuristic and meta-heuristic methods for optimizing resource distribution among cloud data centers were studied in resource allocation papers. These approaches aimed to minimize energy usage while ensuring that resources were distributed effectively to satisfy workload needs. On the other hand, resource utilization articles studied methods to optimize resource use without losing system performance or energy efficiency. By reducing waste and optimizing the use of available resources, these approaches were essential in sustainable cloud computing.

Another important area of study was load balancing algorithms. This category's papers addressed a range of methods intended to divide tasks while taking energy simplicity into consideration. These algorithms were further divided into two categories: dynamic algorithms and static algorithms. Static algorithms manage workloads using preset, fixed distribution techniques that are not updated in real time according to system conditions. On the other hand, dynamic algorithms modify workload distribution in response to current data center conditions, improving system performance and energy efficiency. In cloud environments that vary, these dynamic algorithms were especially useful for optimizing resource utilization.

A tiny percentage of the research for the Performance category focused on real-time cloud services, where it is essential to balance workload distribution while ensuring regular and on-time termination of work. The ability of real-time approaches to ensure low-latency response times and predictable execution was looked at. In order to ensure tasks were scheduled and finished within the specified period of time, these papers focused on making sure load balancing algorithms could adjust to the changing demands of green cloud environments.

Publication type	**2022**	**2023**	**2024**	**Total**	**%**
Conference	3	7	5	15	65.22%
Journal	1	2	5	8	34.78%
Total	**4**	**9**	**10**	**23**	**100%**

Table II: Paper distribution by publication type

The table summarizes the number of publications in conferences and journals from 2022 to 2024. It shows that the majority of publications are from conferences (65.22%) compared to journals (34.78%), with a total of 15 publications over the three years. The number of conference publications peaked in 2023, while journal publications steadily increased from 2022 to 2024.

III. Mapping study results

The results are organized into three main subsections. The first subsection classifies the primary findings according to the research focus area, publication type, and contribution type, as well as the detailed classification scheme previously described. In the second subsection, we present the comprehensive results of our mapping study, which was conducted using 23 selected papers. This subsection includes a comparison-based analysis, highlighting the research contributions, methodologies, scope, limitations, and outcomes of these works [3]. Finally, the third subsection addresses the research gaps identified through our study.

Focus Area	**2022**	**2023**	**2024**	**Total**	**%**
Energy Efficiency	4	8	3	15	35.71%
Load Balancing	0	1	10	11	26.19%
Resource Allocation	2	5	4	11	26.19%
Resource Utilization	0	1	2	3	7.14%
Real Time	0	0	2	2	4.76%
Total	6	14	17	42	100%

Table III: Focus Areas from 2022 to 2024

Table III shows a detailed division of the focus area, based on energy efficiency (15 papers, 35.71%), load balancing (11 papers, 26.19%), resource allocation (11 papers, 26.19%), resource utilization (3 papers, 7.14%), and real time (2 papers, 4.76%).

Contribution Type	**2022**	**2023**	**2024**	**Total**	**%**
Tools	1	1	4	6	7.79%
Methods	3	9	10	22	28.57%
Process	1	8	6	15	19.48%
Models	3	5	8	16	20.78%
Metrics	3	7	8	18	23.38%
Total	11	30	36	77	100%

Table IV: Contribution Types from 2022 to 2024

Papers made between 2022 and 2024 are displayed in a table that is divided into five contribution types: tools, methods, processes, models, and metrics. Out of the 77 total contributions, Methods is the most common one with 28.57%, followed by Metrics (23.38%) and Models (20.78%). Every category represents a different area of contribution focus. Models are abstract or theoretical frameworks of systems; Tools are software or programming languages designed to solve specific problems; Methods offer systematic approaches or techniques. Process contributions focused on workflows and Metrics provide ways to evaluate performance or efficiency, most often through graphs. The total amount of contributions has steadily increased during the last three years.

Research Type	2022	2023	2024	Total	%
Solution Proposal	1	5	3	9	21.43%
Validation Research	0	1	1	2	4.76%
Evaluation Research	2	5	8	15	35.71%
Conceptual Proposal	2	2	1	5	11.90%
Experience Article	0	0	0	0	0.00%
Opinion Article	0	0	0	0	0.00%
Total	5	13	13	31	100%

Table V: Research Types from 2022 to 2024

Table V is about the research types which are divided into solution proposals which focus on presenting a new idea, method, or tool to address an identified issue (9 papers, 21.43%), validation research is to validates a previously proposed solution or method (2 papers, 4.76%), evaluation research is the effectiveness or impact of an existing tool, method, or process is assessed (15 papers, 35.71%), and conceptual proposal involves presenting a new theoretical framework or idea (5 papers, 11.90%). We got zero experience articles and opinion articles.

Figure 4 summaries of the frequency of papers in each category are used to illustrate the mapping. The frequency of publications for each category is the main focus of the results analysis. This allows for the identification of gaps and potential areas for further research by highlighting the categories that have received the most attention in previous studies. We used a bubble plot to report the frequencies. This consists of two x-y scatter plots with bubbles placed where categories intersect. The number of articles in the two categories that correspond to the bubble coordinates determines the size of the bubble.

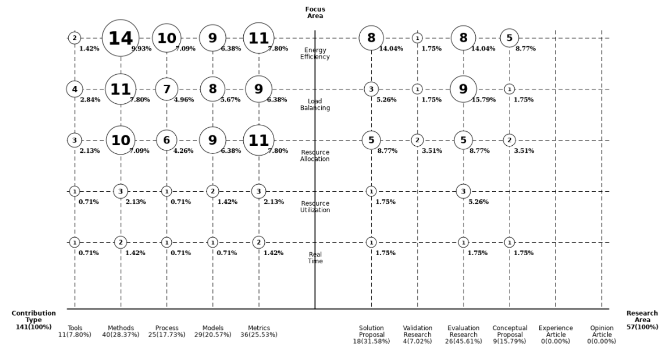

Figure 4: Bubble plot of the mapping study

For the mapping study, we selected 23 papers and did an extensive analysis of them. Our approach included identifying the papers' primary contributions before categorizing them according to our classification scheme, the range of research, and the methodologies. We also went forward and analysed the papers' conclusions before determining whether they were supported by research. We also attempted to identify the constraints or limitations that happen when observing a particular approach in each paper. This method helped us identify the research gaps in the field and effectively organize the research findings inside the green cloud computing field. Future studies in this field are sure to be assisted by the research gaps that have been highlighted.

RQ1-Which topics related to green (sustainable) load balancing algorithms in cloud data centers have been investigated, and to what extent?

Research on cloud data center green load balancing algorithms has focused on several important areas, such as Energy-efficient resource scheduling has been extensively studied. Optimizing resource scheduling to reduce carbon emissions in cloud data centers has been studied by Chitra and Getzi [1]. In a comparable way, Dhaya et al. [13] studied energy-efficient resource allocation and load migration, with a focus on private cloud data centers, which are essential for lowering energy usage.

Dynamic task scheduling for load balancing has been studied to improve performance and resource allocation. Dynamic scheduling techniques were developed by Khan and Sharma [3] to ensure efficient resource distribution. In addition, Yadav and Mishra [2] studied sustainable server utilization in cloud data centers through efficient workload distribution. Algorithms inspired by nature have been studied for load balancing. In order to increase resource allocation and energy efficiency in heterogeneous environments, Tai et al. [11] proposed integrated optimization-based methods. This was further developed by Li et al. [19] with the use of meta-heuristic methods such as ant colony optimization for sustainable load balancing.

Another important area of research has been resource allocation models and energy-efficient protocols. While Kavitha et al. [5] focused on the energy-efficient use of cloud computing environments, Patel and Nayak [10] did a thorough review of numerous protocols and models.

Additional significant variables that have been researched include server usage and energy efficiency. To cut down on energy use, Girsa et al. [8] suggested optimal load balancing techniques. Similar difficulties in achieving energy-efficient load balancing in cloud environments have been identified by Tyagi et al. [12].

Lastly, studies like Malla et al. [9], who created polymorphous energy-efficient resource allocation algorithms in cloud computing, and Badhoutiya [15], who studied ways to make workstations more environmentally friendly, highlighted eco-friendly cloud computing.

RQ2-What types of research methods and contributions have been made in the study of green load balancing algorithms for cloud data centers, and to what extent has each type been represented?

Several research methods have been employed in this field, which have resulted in a wide range of contributions.

Algorithm development has been a key focus in many studies, aiming to create new solutions for energy-efficient load balancing. For example, Girsa et al. [8] proposed optimized algorithms designed to reduce energy consumption, while Anjali et al. [17] developed workflow classification and scheduling methods that enhance energy efficiency in geo-distributed cloud data centers.

Researchers commonly use simulation-based research to validate their proposed algorithms. For example, CloudSim was used by Patel and Nayak [10] to analyze several energy-efficient methods. The same as simulations were used by Kavitha et al. [5] to evaluate the performance of energy-efficient deployment strategies in cloud environments.

Comparative analysis and reviews have assisted to explain current techniques and their effectiveness. In order to improve understanding of sustainable cloud methods, Chauhan et al. [4] studied resource allocation models in cloud data centers, and Shukla et al. [23] studied optimization and load balancing techniques.

Furthermore, theoretical models have been proposed as frameworks for guiding energy-saving strategies. While Kumar and Jindal [16] studied optimizing data centers for environmental sustainability through virtual machine allocation techniques, Rathika and Soranamageswari [20] focused on reducing latency and improving resource allocation efficiency in mobile cloud computing environments.

Task offloading and load migration have become essential methods in cloud computing that use less energy. Wang et al. [21] made significant contributions through their work on task offloading and resource allocation in edge-cloud computing, addressing delay constraints. Amutha et al. [22] studied eco-efficient task scheduling to improve cloud resource allocation and load balancing.

RQ3-In which forums has research on green (sustainable) load balancing algorithms for cloud data centers been published?

The majority of research on green load balancing techniques has been published in two major forums: IEEE and Scopus. IEEE has released a number of significant studies on green cloud computing. Important contributions to this topic have been published by a number of IEEE conferences. To show efforts to improve energy efficiency in cloud data centers, Chitra and Getzi's [1] work on the Green Computing Resource Scheduler was presented at an IEEE conference. By focusing on workload distribution for sustainable server utilization, Yadav and Mishra [2] also made an impact through another IEEE conference. Khan and Sharma [3], who focused on dynamic task scheduling to improve resource allocation, and Chauhan et al. [4], who conducted a comparative analysis of resource allocation techniques, have also contributed to IEEE conferences. Additionally, Kavitha et al. [5] and Kaur et al. [6] presented their research at IEEE conferences on fog-cloud computing and energy-efficient use in cloud environments, respectively. Additional significant presentations at IEEE events consist of the study of energy-efficient algorithms by Vankudre and Rani [7], the optimized load balancing solutions by Girsa et al. [8], and a comprehensive study of protocols and models for cloud computing security and energy efficiency by Patel and Nayak [10]. With their optimization-based algorithm for resource allocation in heterogeneous cloud systems, Tai et al. [11] also made significant contributions through IEEE.

Similar to IEEE, conferences and publications included in the Scopus provided significant innovative research in the field of green cloud computing. While Dhaya et al. [13] contributed by focusing on resource allocation and migration techniques in private cloud data centers, researchers like Tyagi et al. [12] have used Scopus to publish their work on the difficulties of energy-efficient load balancing. Important works like Sharma et al. [17], who studied energy-efficient workflow classification and scheduling in geo-distributed cloud data centers, and Choudhary et al. [18], who analyzed load balancing techniques in cloud computing environments, have also been featured on Scopus platform.

IV. Discussion

The trends show that research increased between 2022 and 2024, however validation studies and solution ideas are still behind, showing a lag in the development and testing of new approaches. Also, real-time applications and resource utilization are underrepresented but are essential for optimizing cloud performance. According to these trends, cloud service providers should give priority to energy-efficient solutions, improve algorithms for load balancing and resource allocation, and implement robust evaluation frameworks. Future research should focus on developing and validating new approaches, improving sustainability metrics, and exploring interdisciplinary approaches to deal with the growing complexity of cloud computing. Journal papers should be given more attention for deeper analysis.

Some potential research gaps in the fields of cloud computing and resource management have been identified based on the data analysis and the focus areas in the graph. These findings draw attention to areas where additional research and development may result in notable advancements in the technology's theoretical and practical aspects. Some of the most important findings are listed below:

1) Emphasis on Efficiency and Load Balancing: The chart indicates a significant focus on efficiency and load balancing, suggesting these are mature areas with substantial research and development activity.
2) Under-Representation of Real-Time Applications: There is a noticeable lack of contributions in the area of real-time applications within cloud computing. Despite the growing demand for real-time capabilities in sectors like finance, healthcare, and communication, the research community appears to be lagging in this domain.
3) Lack of comprehensive approaches to resource utilization: The bubble plot shows that, in comparison to topics like efficiency and load balancing, there is a more limited focus on resource utilization applications. A significant gap exists in developing unified and integrated frameworks that can optimize real-time environments.

For cloud computing research to produce credible and trustworthy results, validity threats must be addressed. It prevents on researcher bias, guarantees that conclusions are based in reality, and improves the findings' applicability to actual situations [26]. Ampatzoglou et al. [25] raise attention to the importance of selection bias as a common risk in secondary studies, where the selection of papers or sources might alter findings by neglecting certain areas of study. There are concerns regarding the findings' generalizability because the chosen data might not accurately reflect the whole field of study. The fact that the research did not include the term "real-time application" in the search string could affect the validity of the study. This might have caused relevant research that concentrate on real-time systems to be excluded, which could have affected our findings by removing significant papers in this field. As a result, the findings may not be as applicable to real-time applications as they could be.

V. Conclusion and Future Work

Through our systematic mapping study on green cloud computing, we were able to recognize that the real-time capability of systems is not taken into account in many studies. It can happen that the real-time capability of critical systems can be at risk by a permanent optimization of the other topic areas. On the other hand, it focused on energy efficiency, which is the most important factor to achieve green and sustainable cloud computing.

The focus of future work should continue to be on energy efficiency and areas that improve it, because this is the factor that enables a green and sustainable cloud. However, more studies should research the real-time capability and delay of cloud applications, as these may be endangered by applications optimized for energy efficiency. Using AI and machine learning together has a lot of potential to produce flexible, energy-saving solutions. The gap between theory and practice can be filled in part by carrying out industrial case studies and conducting additional research on hybrid cloud environments. In order to motivate innovation and establish standards for more environmentally friendly cloud computing techniques, it will also be essential to establish standardized sustainability metrics and increase multidisciplinary collaboration.

REFERENCES

[1] K. Chitra and M. Getzi, "GCRS – Green Computing Resource Scheduler: An Optimized Energy Efficient Cloud Data Centers to Scale Down Carbon Emission," 2023 International Conference on Self Sustainable Artificial Intelligence Systems (ICSSAS), Erode, India, 2023, pp. 1091-1098, doi: 10.1109/ICSSAS57918.2023.10331632.

[2] M. Yadav and A. Mishra, "Efficient Workload Distribution for Sustainable Server Utilization in Cloud Data Centers," 2024 International Conference on Intelligent Systems for Cybersecurity (ISCS), Gurugram, India, 2024, pp. 1-6, doi: 10.1109/ISCS61804.2024.10581223.

[3] M. I. Khan and K. Sharma, "Dynamic Task Scheduling for Load Balancing in Cloud Environments to Enhance Resource Allocation and Performance Efficiency," 2024 International Conference on Innovations and Challenges in Emerging Technologies (ICICET), Nagpur, India, 2024, pp. 1-6, doi: 10.1109/ICICET59348.2024.10616342.

[4] N. Chauhan, N. Kaur and K. S. Saini, "Energy Efficient Resource Allocation in Cloud Data Center: A Comparative Analysis," 2022 International Conference on Computational Modelling, Simulation and Optimization (ICCMSO), Pathum Thani, Thailand, 2022, pp. 201-206, doi: 10.1109/ICCMSO58359.2022.00049.

[5] J. Kavitha, P. S. V. S. Rao and G. C. Babu, "Energy Efficient Resource Utilization of Cloud Computing Environments for Deployment Models," 2023 Second International Conference on Augmented Intelligence and Sustainable Systems (ICAISS), Trichy, India, 2023, pp. 1111-1119, doi: 10.1109/ICAISS58487.2023.10250648.

[6] M. Kaur, R. Aron and S. Seth, "Optimizing Resource Allocation for Energy Efficiency in Fog Cloud Computing Environments," 2024 IEEE 13th International Conference on Communication Systems and Network Technologies (CSNT), Jabalpur, India, 2024, pp. 538-542, doi: 10.1109/CSNT60213.2024.10545889.

[7] A. Vankudre and V. R. J, "Energy Efficient Algorithms in Green Cloud Computing- A Comprehensive Study," 2023 14th International Conference on Computing Communication and Networking Technologies (ICCCNT), Delhi, India, 2023, pp. 1-7, doi: 10.1109/ICCCNT56998.2023.10306976.

[8] D. Girsa, D. Chauhan and D. Sharma, "Optimised Load Balancing for Green Cloud Computing," 2023 13th International Conference on Cloud Computing, Data Science & Engineering (Confluence), Noida, India, 2023, pp. 171-175, doi: 10.1109/Confluence56041.2023.10048811.

[9] P. A. Malla, S. Sheikh and T. A. Teli, "A Polymorphous Energy Efficient Resource Allocation Approach (PEERA) in Cloud Computing," 2023 10th International Conference on Computing for Sustainable Global Development (INDIACom), New Delhi, India, 2023, pp. 920-923.

[10] S. Patel and A. Nayak, "A Comprehensive Analysis of Protocols and Models for Improving Energy Efficiency and Security in Cloud Computing," 2023 Global Conference on Information Technologies and Communications (GCITC), Bangalore, India, 2023, pp. 1-5, doi: 10.1109/GCITC60406.2023.10426325.

[11] K. -Y. Tai, F. Y. -S. Lin and C. -H. Hsiao, "An Integrated Optimization-Based Algorithm for Energy Efficiency and Resource Allocation in Heterogeneous Cloud Computing Centers," in IEEE Access, vol. 11, pp. 53418-53428, 2023, doi: 10.1109/ACCESS.2023.3280930.

[12] U. Tyagi, V. Bansal, S. Singhal and T. Gupta, "Challenges and issues in energy efficient load balancing in the cloud computing environment," 2022 International Conference on Machine Learning, Big Data, Cloud and Parallel Computing (COM-IT-CON), Faridabad, India, 2022, pp. 634-638, doi: 10.1109/COM-IT-CON54601.2022.9850861.

[13] Dhaya R., U. U. J., Sharma T., Singh P., Kanthavel R., Selvan S., and Krah D., "Energy-Efficient Resource Allocation and Migration in Private Cloud Data Centre," Wireless Communications and Mobile Computing, 2022.

[14] Geetanjali and S. J. Quraishi, "Energy Savings using Green Cloud Computing," 2022 Third International Conference on Intelligent Computing Instrumentation and Control Technologies (ICICICT), Kannur, India, 2022, pp. 1496-1500, doi: 10.1109/ICICICT54557.2022.9917654.

[15] A. Badhoutiya, "Green Cloud Computing- Next Step Towards Eco-friendly Work Stations," 2022 6th International Conference on Electronics, Communication and Aerospace Technology, Coimbatore, India, 2022, pp. 809-813, doi: 10.1109/ICECA55336.2022.10009629.

[16] V. Kumar and B. Jindal, "Optimizing Cloud Data Centers for Environment Sustainability through Performance-Aware Virtual Machine Allocation," 2023 7th International Conference on Electronics, Materials Engineering & Nano-Technology (IEMENTech), Kolkata, India, 2023, pp. 1-6, doi: 10.1109/IEMENTech60402.2023.10423489.

[17] A. P. Sharma, J. Singh, Y. Gulzar, D. Gupta, and M. Kumar, "Sustainable energy efficient workflow classification and scheduling in geo distributed cloud datacenter," Discov. Sustain., vol. 5, no. 1, p. 128, 2024.

[18] A. Choudhary, R. Rajak, and S. Prakash, "A Critical Review and Analysis of Load Balancing Methods in Cloud Computing Environment," Wireless Personal Communications, vol. 137, no. 4, pp. 2145-2165, 2024.

[19] P. Li, H. Wang, G. Tian, and Z. Fan, "Towards Sustainable Cloud Computing: Load Balancing with Nature-Inspired Meta-Heuristic Algorithms," Electronics, vol. 13, no. 13, p. 2578, 2024.

[20] J. Rathika and M. Soranamageswari, "Energy Efficient Resource Allocation and Latency Reduction in Mobile Cloud Computing Environments," Wireless Personal Communications, vol. 136, no. 2, pp. 657-687, 2024.

[21] S. Wang, X. Li, and Y. Gong, "Energy-Efficient Task Offloading and Resource Allocation for Delay-Constrained Edge-Cloud Computing Networks," IEEE Transactions on Green Communications and Networking, vol. 8, no. 1, pp. 514-524, 2024.

[22] S. Amutha et al., "Optimizing Cloud Resource Allocation and Load Balancing through Eco-Efficient Task Scheduling," International Journal of Intelligent Systems and Applications in Engineering, vol. 12, no. 11s, pp. 137-143, 2024.

[23] R. N. Shukla et al., "ECCO: Cloud Energy Optimization and Load

Balancing," in Lecture Notes in Networks and Systems, vol. 995, pp. 211-224, 2024.

[24] K. Petersen, R. Feldt, S. Mujtaba, and M. Mattsson, "Systematic mapping studies in software engineering," in 12th International Conference on Evaluation and Assessment in Software Engineering (EASE), 2008, pp. 1-10.

[25] Ampatzoglou et al., 2019] Apostolos Ampatzoglou, Stamatia Bibi, Paris Avgeriou, Marijn Verbeek, Alexander Chatzigeorgiou: Identifying, categorizing and mitigating threats to validity in software engineering secondary studies. Inf. Softw. Technol. 106: 201-230 (2019)

[26] N. Mustafa, Y. Labiche and D. Towey, "Mitigating Threats to Validity in Empirical Software Engineering: A Traceability Case Study," 2019 IEEE 43rd Annual Computer Software and Applications Conference (COMPSAC), Milwaukee, WI, USA, 2019, pp. 324-329