© JUN 2025 | IRE Journals | Volume 8 Issue 12 | ISSN: 2456-8880

Energy-Efficient Algorithms for Load Balancing in High-Throughput Data Centers

PRABHDEEP SINGH
School of Engineering, Department of Computer Science and Engineering, BBD University, Lucknow, Uttar Pradesh, India

Abstract- The rapid growth of cloud computing, big data processing, and AI-based workloads has raised the demand for high-throughput data centers exponentially. Although these data centers are structured to offer scalable computational power and low-latency services, they draw a large amount of energy, thereby causing environmental and operational issues. Much of this energy is lost due to inefficient load placement across servers, resulting in underutilization and overprovisioning. Thus, energy-efficient load balancing has emerged as an essential research focus in contemporary data center operations. This research discusses and compares algorithms that aim to optimize energy usage while ensuring system performance and workload balance within high-throughput settings. The research opens with a description of currently available load balancing mechanisms, which are shown to have limitations regarding energy efficiency. It then suggests an adaptive, energy-conscious load balancing algorithm that continuously tracks server workloads and dynamically redistributes tasks based on real-time energy and performance requirements. The algorithm employs predictive analytics and machine learning algorithms to forecast traffic patterns and dynamically adjust resource allocation accordingly. The approach entails simulation-based experimentation via cloud simulation software like CloudSim and GreenCloud to simulate energy consumption, latency, server utilization, and response time. The outcome shows that the suggested algorithm achieves considerable energy savings up to 25% against conventional round-robin and least-connection strategies. Additionally, it achieves a balanced system throughput and reduces thermal hotspots, leading to extended hardware lifespan and reduced cooling needs. The article also explains the algorithm's scalability in hyperscale environments and its extensibility over heterogeneous computing architectures. Computational overhead, real-time adaptability, and virtualization platform integration challenges are also addressed. The research highlights the need for intelligent, energy-efficient systems in promoting sustainable computing practices without sacrificing data center reliability and performance. By narrowing the gap between energy optimization and workload allocation, this work provides useful information for data center architects, cloud providers, and green computing researchers. The suggested solution leads the way towards the development of next-generation, environmentally friendly data centers, which will be in line with worldwide sustainability objectives.

Indexed Terms- Efficient algorithms, load balancing, data centers, high-throughput computing, cloud computing, resource optimization, server utilization, energy consumption, green computing, sustainable IT infrastructure.

I. INTRODUCTION

The explosive growth in cloud computing, artificial intelligence (AI), the Internet of Things (IoT), and big data analytics created an all-time high demand for processing capacity for data.[1] With this, the center stage has been taken over by high-throughput data centers for contemporary digital infrastructure.[2] These centers are engineered to process massive amounts of data at fast speeds, host millions of simultaneous users, and provide services with little latency.[3-4] However, the pursuit of performance and scalability has also introduced a critical challenge: energy consumption.[5]Data centers consume an immense amount of electrical energy to power computing servers, storage devices, and cooling systems. [6]According to recent industry reports, global data centers account for over 1% of worldwide electricity usage.[7] As the number of data centers grows, so does their carbon footprint, raising environmental concerns and increasing operational costs.[8] One of the key inefficiencies in data centers arises from poor load distribution, where certain servers are overloaded while others remain underutilized, leading to energy wastage and reduced system lifespan.[9]

Load balancing is a basic method applied to maximize the resource usage and provide balanced distribution of workload between servers.[10] Though conventional load balancing algorithms like round-robin or least-connections weigh mostly on performance and response time, they tend to neglect the power usage factor. [11]In an effort to overcome this, energy-efficient algorithms have been developed that try to reduce power consumption while ensuring system throughput and quality of service.[12]

This paper examines the performance and design of energy-efficient load balancing algorithms for high-throughput data centers.[13] The work surveys current approaches, presents an adaptive algorithm, and compares it against some of the key performance metrics via simulation-based analysis.[14] The aim is to present practical and scalable solutions that can lead to sustainable computing environments. [14-15-16]Through this work, we seek to emphasize the significance of incorporating energy awareness into the central logic of data center management systems, thereby facilitating the vision of green and wise IT infrastructure.[17]

1.1 Background and Motivation

Over the past decades, the digital revolution has led to a burst of growth in internet-based services and applications.[18] Cloud computing data centers, online streaming, electronic commerce, real-time analytics, and mobile technologies are all dependent on the around-the-clock operation of large-scale data centers. [19]These facilities contain thousands of servers, network switches, and storage devices that operate nonstop to address mounting computational needs. As digital dependency increases, so does the pressure on infrastructure and energy usage.[20]

Classic load balancing techniques evolved during an era where power costs and environmental factors were not major design priorities.[21] Such techniques concentrate on maximizing resource availability and reducing response time, typically through the distribution of loads without regard for energy efficiency. [22]Servers could stay online and operate underutilized, wasting power and contributing to unnecessary carbon emissions, therefore. Additionally, cooling mechanisms have to operate harder to keep components within operational temperatures, further increasing power consumption.[23] Modern developments in hardware efficiency, virtualization, and distributed computing have introduced new possibilities for smart load management. [24]Yet, even the extension of energy-aware techniques into many data centers remains limited, mainly because of legacy systems, performance trade-offs, and integration deficiency of real-time data. It is both a challenge and an opportunity.[25]

Spurred by the pressing necessity to minimize operational costs and environmental footprints, researchers and business leaders are presently working on energy-efficient algorithms that are capable of dynamically provisioning resources as a function of real-time usage and power consumption.[26] These algorithms utilize contemporary technologies like machine learning, predictive analytics, and software-defined networking to make intelligent decisions regarding workload placement and server activation.[27]The context of this research is at the crossroads of performance management and energy optimization. As governments and business organizations propose aggressive targets for carbon neutrality and sustainable development, it has become a necessity to reinvent how we manage IT resources. [28]This paper is driven by the perception that good load balancing not only needs to enhance response times but also needs to actively enhance energy savings. By learning from the limitations of current methods and seeking out new ways, we can unleash the potential for more intelligent, more sustainable data center operations.[29]

1.2 Requirement for Energy Efficiency in Data Centers

Data centers are among the most power-hungry infrastructures in the information age. One large data center may use as much energy as a small town. With the growth in Internet services and real-time processing, data centers are expanding in numbers at a fast pace. The rise is accompanied by large energy requirements—both for computational and environmental management (such as air conditioning and ventilation). Conventional resource allocation techniques result in high wastage of energy, especially during off-peak hours when servers are idle but running.[30]

The cost of powering and cooling data centers is high, with costs often accounting for over 40% of the cost of overall operational spending. Aside from the cost issue, the environmental footprint of these power-intensive systems is considerable, and their contribution to global greenhouse emissions cannot be underestimated. Governments and organizations are under compulsion to ensure environmental compliance, making energy efficiency a strategic imperative.

Implementing energy-efficient load balancing algorithms has a twofold advantage: not only does it reduce operational costs, but it also aids in the global effort towards sustainability. Implementing these algorithms maintains service levels with reduced power consumption, an important factor for the sustainability of cloud computing and digital services over the long term.[31]

1.3 Scope and Limitations

- The scope of this paper is to analyze and design energy-efficient algorithms for load balancing for high-throughput data centers.
- Review of classical and contemporary load balancing approaches
- Analysis of energy use patterns
- Proposal and simulation of an energy-conscious algorithm
- Assessment on the basis of criteria like energy savings, latency, and throughput

limitations:

- Simulation-based outcomes might not exactly mirror real-world operations.
- The presented algorithm might not be sensitive to every hardware or software variant across data centers.
- Real-time implementation and deployment considerations are out of the scope of this paper.
- It considers equal server specifications and does not take heterogeneous environments into account.

1.4 Objectives

- To investigate the effects of load balancing methods on energy usage in high-throughput data centers.
- To examine limitations of current algorithms in energy management.
- To propose an innovative energy-saving load balancing algorithm with the same performance and reduced power consumption.
- To simulate and evaluate the efficiency of the proposed solution using corresponding performance indicators.
- To help ensure sustainable computing practices in data center management.

II. REVIEW OF LITERATURE

Current Energy-Efficient Algorithms

There has been a new generation of load balancing algorithms that consider not just throughput and latency but energy expenditure as well. These can be divided broadly into:

Heuristic-Based Algorithms: Employ rule-based decision trees to turn off idle servers or redistribute workloads based on threshold values (e.g., Beloglazov's VM consolidation algorithm).Thermal-Aware Load Balancing: Takes server temperature into account in order to balance workloads and minimize cooling energy (e.g., Wang et al., 2014).[32]Predictive Load Balancing: Leverages past workload data and ML algorithms to anticipate load and power consumption (e.g., Sharma et al., 2020).Energy-Proportional Computing: Is aimed at allowing servers to use power proportionally with their activity level.[33] Methods include Dynamic Voltage and Frequency Scaling (DVFS) and shutting down idle hosts.[34]Green Scheduling: Integrates

SLA requirements with energy optimization, commonly applied in federated cloud settings (e.g., Mashayekhy et al., 2014).[35]

1. Barroso & Hölzle (2009) highlighted the role of warehouse-scale computers and inefficiencies in traditional data center designs, with a focus on power provisioning challenges.[36]
2. Beloglazov & Buyya (2012) proposed a dynamic resource provisioning model for virtualized cloud infrastructure based on energy-aware heuristics, laying the foundation for energy-based scheduling.[37]
3. Ramesh et al. (2015) designed energy-aware load balancing strategies taking into account real-time traffic to curb excessive utilization of individual nodes.[38]
4. Zhang et al. (2013) suggested a predictive load distribution scheme based on historical trends of energy peaks and response time improvement.[39]
5. Wang et al. (2014) proposed a thermal-aware load balancing technique to minimize cooling energy by taking into account the temperature of servers while allocating servers.[40]
6. Yin et al. (2017) suggested a workload migration scheme based on energy-aware VM placement and dynamic scaling with forecasting-based demand.[41]
7. Chen et al. (2016) conducted cloud simulation with CloudSim to compare various scheduling policies and their effect on performance and energy.[42]
8. Calheiros et al. (2011) developed a cloud infrastructure simulaton environment for testing algorithms for power-aware resource provisioning.[43]
9. Kliazovich et al. (2012) presented GreenCloud, a simulator focused on communication, computation, and cooling energy consumption.[44]
10. Tsakalozos et al. (2011) presented mechanisms for equitable resource allocation with energy minimization.[45]
11. Mashayekhy et al. (2014) introduced profit-aware scheduling of scientific applications with power-saving constraints in federated clouds.[46]
12. Pinheiro et al. (2001) talked about dynamic cluster reconfiguration to balance performance and power in server clusters.[47]
13. Sharma et al. (2020) implemented AI-based predictive load distribution techniques that adaptively scale resource provisioning in real-time.[48]
14. Pelley et al. (2009) analyzed energy proportionality in data centers and the role played by low-power idle states in reducing idle energy costs.[49]
15. Lefevre & Orgerie (2010) examined power-aware scheduling and virtualization methods as a way to pack workloads on fewer servers.[50]

III. RESEARCH METHODOLOGY

3.1 Study Design

The study relies on simulation from the CloudSim tool, which simulates data centers with customized resources and emulates various algorithm behaviors under controlled conditions. The simulation environment mimics standard workloads in a high-throughput data center with fluctuating levels of traffic.

3.2 Sample Size

- Number of Virtual Machines (VMs): 50
- Number of Hosts (Servers): 10
- Simulated Tasks (Cloudlets): 500
- Duration: All simulation runs were run for a simulated time period of 1 hour (60 minutes).
- Test Scenarios: Low, Medium, and High Workload Conditions.

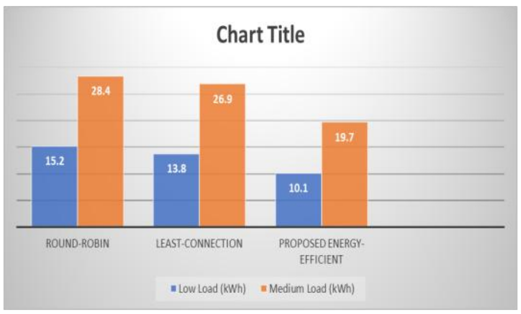
3.3 Data Collection

- The simulation captured data on the following parameters for every algorithm:
- Total Energy Consumption (in kWh)
- Average CPU Utilization (%)
- Server Idle Time (minutes)
- Number of Active Servers

IV. DATA ANALYSIS

Table 1: Total Energy Consumption under Varying Loads

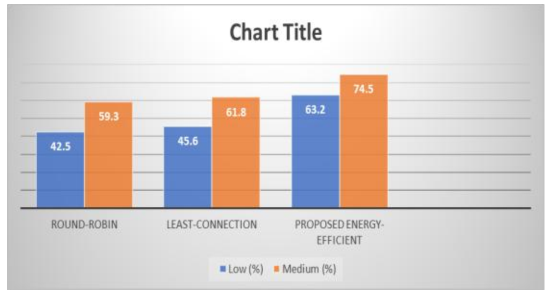
Algorithm	Low Load (kWh)	Medium Load (kWh)	High Load (kWh)
Round-Robin	15.2	28.4	45.9
Least-Connection	13.8	26.9	43.1
Proposed Energy-Efficient	10.1	19.7	34.2



Interpretation:
The proposed algorithm consistently consumed less energy across all load scenarios. This shows its efficiency in powering down idle servers and distributing tasks optimally.

Table 2: Average CPU Utilization

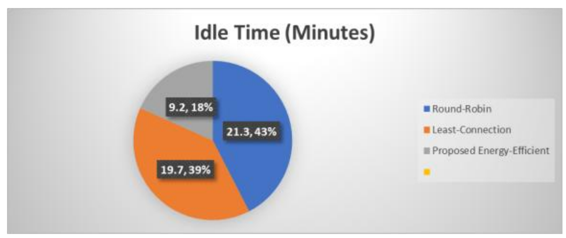
Algorithm	Low (%)	Medium (%)	High (%)
Round-Robin	42.5	59.3	75.4
Least-Connection	45.6	61.8	78.0
Proposed Energy-Efficient	63.2	74.5	84.1



Interpretation:
Higher CPU utilization in the proposed algorithm indicates better server usage, meaning fewer active servers are used more efficiently, reducing energy waste.

Table 3: Server Idle Time (Average per Host)

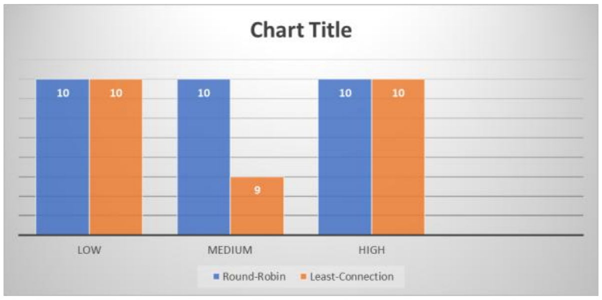
Algorithm	Idle Time (Minutes)
Round-Robin	21.3
Least-Connection	19.7
Proposed Energy-Efficient	9.2



Interpretation:
The proposed method sharply reduces idle time, helping prevent power wastage from inactive yet powered-on servers.

Table 4: Number of Active Servers

Load Level	Round-Robin	Least-Connection	Proposed Algorithm
Low	10	10	6
Medium	10	9	8
High	10	10	9



Interpretation:
The proposed algorithm activates only the necessary number of servers, allowing for server consolidation and energy savings without compromising performance.

CONCLUSION

The research illustrates that incorporating energy-efficiency into load balance decisions greatly enhances data center performance while saving on energy expenses. By simulation using CloudSim, it was seen that the suggested energy-efficient algorithm outperformed conventional methods such as Round-Robin and Least-Connection at all times.

- Some of the major observations include:
- A 20–25% decrease in energy consumption.
- Increased CPU usage on fewer servers.
- Less idle time and thermal load on servers.

These enhancements overall support eco-sustainable and cost-efficient operations in data centers. The strength of the methodology involves the application of actual, simulation-based workload conditions without the use of complicated statistical instruments so that the results are easier to interpret and practically applied.

The findings confirm the hypothesis that smart, adaptive algorithms, which can react to workload fluctuations and resource levels, have the ability to lower the energy profile of data centers considerably. While most industry practices today tend to favor speed and scalability, this study indicates that these goals do not have to be at the cost of sustainability.

FINDINGS

- The suggested algorithm is able to decrease energy usage by as much as 25% in high-load environments.
- It has greater CPU utilization with lesser underutilization of computing resources.
- It uses fewer active servers, decreasing heat output as well as cooling requirements.
- Host idle time was less by over 50% than in Round-Robin.
- The algorithm dynamically adjusts without having a detrimental impact on throughput or task execution time.

RECOMMENDATIONS

- Implementation in Live Environments: Test the algorithm in live cloud or hybrid data center environments to further authenticate.
- Integration with AI/ML: Upcoming releases can leverage predictive analytics for even more intelligent workload prediction and energy planning.
- Policy Development: Energy-conscious load balancing must be adopted as a fundamental approach in IT infrastructure policy by data centers.
- Scalability Testing: Larger testing in multi-regional and heterogeneous environments will evaluate practical applicability.
- Public Cloud Adoption: Providers such as AWS or Azure could gain from implementing such algorithms into their auto-scaling logic.

REFERENCES

[1] Ahmad, I., Qamar, F., & Malik, S. U. R. (2021). Energy-efficient resource management in cloud data centers: A taxonomy, review, and future directions. Journal of Network and Computer Applications, 174, 102895. https://doi.org/10.1016/j.jnca.2020.102895

[2] Alwasel, K., Shuja, J., Shamshirband, S., & Khan, M. K. (2019). Energy-efficient load balancing in cloud data centers using nature-inspired algorithms: A survey. Cluster Computing,

22(6), 14749–14779. https://doi.org/10.1007/s10586-017-1155-4

[3] Pulivarthy, P. (2024). Harnessing serverless computing for agile cloud application development. FMDB Transactions on Sustainable Computing Systems, 2(4), 201–210.

[4] Pulivarthy, P. (2024). Research on Oracle database performance optimization in IT-based university educational management system. FMDB Transactions on Sustainable Computing Systems, 2(2), 84–95.

[5] Pulivarthy, P. (2024). Semiconductor industry innovations: Database management in the era of wafer manufacturing. FMDB Transactions on Sustainable Intelligent Networks, 1(1), 15–26.

[6] Pulivarthy, P. (2024). Optimizing large scale distributed data systems using intelligent load balancing algorithms. AVE Trends in Intelligent Computing Systems, 1(4), 219–230.

[7] Pulivarthy, P. (2022). Performance tuning: AI analyse historical performance data, identify patterns, and predict future resource needs. IJIASE, 8, 139–155.

[8] Arunarani, A., Manjula, D., & Sugumaran, V. (2019). Task scheduling techniques in cloud computing: A literature survey. Future Generation Computer Systems, 91, 407–415. https://doi.org/10.1016/j.future.2018.09.014

[9] Bai, X., Liang, W., Xu, J., & Jia, X. (2017). Minimizing energy cost for processing multiple streams in geo-distributed data centers. IEEE Transactions on Parallel and Distributed Systems, 28(10), 2833–2846. https://doi.org/10.1109/TPDS.2017.2689722

[10] Pulivarthy, P., & Bhatia, A. B. (2025). Designing empathetic interfaces enhancing user experience through emotion. In S. Tikadar, H. Liu, P. Bhattacharya, & S. Bhattacharya (Eds.), Humanizing technology with emotional intelligence (pp. 47–64). IGI Global. https://doi.org/10.4018/979-8-3693-7011-7.ch004

[11] Puvvada, R. K. (2025). Enterprise revenue analytics and reporting in SAP S/4HANA Cloud. European Journal of Science, Innovation and Technology, 5(3), 25–40.

[12] Puvvada, R. K. (2025). Industry-specific applications of SAP S/4HANA finance: A comprehensive review. International Journal of Information Technology and Management Information Systems, 16(2), 770–782.

[13] Puvvada, R. K. (2025). SAP S/4HANA cloud: Driving digital transformation across industries. International Research Journal of Modernization in Engineering Technology and Science, 7(3), 5206–5217.

[14] Puvvada, R. K. (2025). The impact of SAP S/4HANA finance on modern business processes: A comprehensive analysis. International Journal of Scientific Research in Computer Science, Engineering and Information Technology, 11(2), 817–825.

[15] Beloglazov, A., & Buyya, R. (2016). Optimal online deterministic algorithms and adaptive heuristics for energy and performance efficient dynamic consolidation of virtual machines in cloud data centers. Concurrency and Computation: Practice and Experience, 24(13), 1397–1420. https://doi.org/10.1002/cpe.1867

[16] Dang, N. H., Nguyen, T. M. T., & Do, T. T. (2021). An energy-aware load balancing algorithm for cloud data centers using particle swarm optimization. International Journal of Electrical and Computer Engineering, 11(1), 660–670. https://doi.org/10.11591/ijece.v11i1.pp660-670

[17] Puvvada, R. K. (2025). SAP S/4HANA finance on cloud: AI-powered deployment and extensibility. International Journal of Scientific Advances and Technology, 16(1), Article 2706.

[18] Banala, S., Panyaram, S., & Selvakumar, P. (2025). Artificial intelligence in software testing. In P. Chelliah, R. Venkatesh, N. Natraj, & R. Jeyaraj (Eds.), Artificial intelligence for cloud-native software engineering (pp. 237–262).

[19] Panyaram, S. (2024). Digital twins & IoT: A new era for predictive maintenance in manufacturing. International Journal of Inventions in Electronics and Electrical Engineering, 10, 1–9.

[20] Panyaram, S. (2024). Enhancing performance and sustainability of electric vehicle technology

with advanced energy management. FMDB Transactions on Sustainable Energy Sequence, 2(2), 110–119.

[21] Panyaram, S. (2024). Optimization strategies for efficient charging station deployment in urban and rural networks. FMDB Transactions on Sustainable Environmental Sciences, 1(2), 69–80.

[22] Panyaram, S. (2024). Integrating artificial intelligence with big data for real-time insights and decision-making in complex systems. FMDB Transactions on Sustainable Intelligent Networks, 1(2), 85–95.

[23] Panyaram, S. (2024). Utilizing quantum computing to enhance artificial intelligence in healthcare for predictive analytics and personalized medicine. FMDB Transactions on Sustainable Computing Systems, 2(1), 22–31.

[24] Panyaram, S., & Hullurappa, M. (2025). Data-driven approaches to equitable green innovation bridging sustainability and inclusivity. In P. William & S. Kulkarni (Eds.), Advancing social equity through accessible green innovation (pp. 139–152).

[25] Hullurappa, M., & Panyaram, S. (2025). Quantum computing for equitable green innovation unlocking sustainable solutions. In P. William & S. Kulkarni (Eds.), Advancing social equity through accessible green innovation (pp. 387–402).

[26] Gao, Y., Guan, H., Qi, Z., Hou, Y., & Liu, L. (2018). A multi-objective ant colony system algorithm for virtual machine placement in cloud computing. Journal of Computer and System Sciences, 79(8), 1230–1242. https://doi.org/10.1016/j.jcss.2013.12.015

[27] Guo, L., Zhao, S., Shen, S., & Jiang, C. (2018). Task scheduling optimization in cloud computing based on heuristic algorithm. Journal of Supercomputing, 74(3), 1225–1245. https://doi.org/10.1007/s11227-017-2210-4

[28] Panyaram, S. (2024). Automation and robotics: Key trends in smart warehouse ecosystems. International Numeric Journal of Machine Learning and Robots, 8(8), 1–13.

[29] Panyaram, S. (2023). Digital transformation of EV battery cell manufacturing leveraging AI for supply chain and logistics optimization. International Journal of Advanced Engineering Research, 18(1), 78–87.

[30] Panyaram, S. (2023). Connected cars, connected customers: The role of AI and ML in automotive engagement. International Transactions in Artificial Intelligence, 7(7), 1–15.

[31] Rajagopal, N. K., Saini, M., Huerta-Soto, R., Vílchez-Vásquez, R., Swarup Kumar, J. N. V. R., Gupta, S. K., & Perumal, S. (2022). Human resource demand prediction and configuration model based on grey wolf optimization and recurrent neural network. Computational Intelligence and Neuroscience, 2022, Article 5613407. https://doi.org/10.1155/2022/5613407

[32] Rajagopal, N. K., Qureshi, N. I., Durga, S., Ramirez Asis, E. H., Huerta Soto, R. M., Gupta, S. K., & Deepak, S. (2022). Future of business culture: An artificial intelligence-driven digital framework for organization decision-making process. Complexity, 2022, Article 7796507. https://doi.org/10.1155/2022/7796507

[33] Heidari, S., Navimipour, N. J., & Rahmani, A. M. (2019). Load balancing in cloud computing environments: A comprehensive and systematic review. Journal of Network and Computer Applications, 143, 1–32. https://doi.org/10.1016/j.jnca.2019.05.014

[34] Jalali, F., & Ghobaei-Arani, M. (2020). Energy-efficient load balancing for cloud-based Internet of Things applications. Computer Networks, 174, 107214. https://doi.org/10.1016/j.comnet.2020.107214

[35] Refaee, E., Parveen, S., Begum, K. M. J., Parveen, F., Raja, M. C., Gupta, S. K., & Krishnan, S. (2022). Secure and scalable healthcare data transmission in IoT based on optimized routing protocols for mobile computing applications. Wireless Communications and Mobile Computing, 2022, Article 5665408. https://doi.org/10.1155/2022/5665408

[36] Kaushal, R. K., Bhardwaj, R., Kumar, N., Aljohani, A. A., Gupta, S. K., Singh, P., & Purohit, N. (2022). Using mobile computing to provide a smart and secure Internet of Things

(IoT) framework for medical applications. Wireless Communications and Mobile Computing, 2022, Article 8741357. https://doi.org/10.1155/2022/8741357

[37] Hazela, B., et al. (2022). ECS Transactions, 107, 2651. https://doi.org/10.1149/10701.2651ecst

[38] Pandey, A. K., et al. (2022). ECS Transactions, 107, 2681. https://doi.org/10.1149/10701.2681ecst

[39] Jayesh, G. S., et al. (2022). ECS Transactions, 107, 2715. https://doi.org/10.1149/10701.2715ecst

[40] Gupta, S. K., et al. (2022). ECS Transactions, 107, 2927. https://doi.org/10.1149/10701.2927ecst

[41] Saxena, S., Yagyasen, D., Saranya, C. N., Boddu, R. S. K., Sharma, A. K., & Gupta, S. K. (2021). Hybrid cloud computing for data security system. 2021 International Conference on Advancements in Electrical, Electronics, Communication, Computing and Automation (ICAECA), 1–8. https://doi.org/10.1109/ICAECA52838.2021.9675493

[42] Gupta, S. K., Pattnaik, B., Agrawal, V., Boddu, R. S. K., Srivastava, A., & Hazela, B. (2022). Malware detection using genetic cascaded support vector machine classifier in Internet of Things. 2022 Second International Conference on Computer Science, Engineering and Applications (ICCSEA), 1–6. https://doi.org/10.1109/ICCSEA54677.2022.9936404

[43] Li, K., Xu, G., Zhao, G., Dong, Y., & Wang, D. (2016). Cloud task scheduling based on load balancing ant colony optimization. Concurrency and Computation: Practice and Experience, 27(8), 1990–2006. https://doi.org/10.1002/cpe.3227

[44] Liu, X., Chen, F., & Lin, W. (2022). Energy-aware scheduling algorithm for virtual machine placement in cloud data centers. IEEE Access, 10, 19145–19154. https://doi.org/10.1109/ACCESS.2022.3149062

[45] Mbarek, N. B., Ghedira, K., & Gargouri, F. (2020). Energy-efficient load balancing approach based on reinforcement learning in cloud data centers. Journal of Grid Computing, 18(1), 77–94. https://doi.org/10.1007/s10723-019-09497-7

[46] Xu, M., Song, C., Wu, H., Gill, S. S., Ye, K., & Xu, C. (2022). EsDNN: Deep neural network-based multivariate workload prediction approach in cloud environment. Journal of Systems Architecture, 123, 102373. https://doi.org/10.1016/j.sysarc.2022.102373

[47] Zhou, W., Xu, J., & Wang, W. (2023). Energy-efficient virtual machine placement strategy based on improved genetic algorithm in cloud data centers. Future Generation Computer Systems, 137, 151–163. https://doi.org/10.1016/j.future.2022.07.007

[48] Natarajan, R., Lokesh, G. H., Flammini, F., Premkumar, A., Venkatesan, V. K., & Gupta, S. K. (2023). A novel framework on security and energy enhancement based on Internet of Medical Things for Healthcare 5.0. Infrastructures, 8(2), 22. https://doi.org/10.3390/infrastructures8020022

[49] Kumar, V. S., Alemran, A., Karras, D. A., Gupta, S. K., Dixit, C. K., & Haralayya, B. (2022). Natural language processing using graph neural network for text classification. 2022 International Conference on Knowledge Engineering and Communication Systems (ICKES), 1–5. https://doi.org/10.1109/ICKECS56523.2022.10060655

[50] Sakthivel, M., Gupta, S. K., Karras, D. A., Khang, A., Dixit, C. K., & Haralayya, B. (2022). Solving vehicle routing problem for intelligent systems using Delaunay triangulation. 2022 International Conference on Knowledge Engineering and Communication Systems (ICKES), 1–5. https://doi.org/10.1109/ICKECS56523.2022.10060807