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Energy Aware VM Migration Using Firefly Optimization Algorithm (FA-VM)

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Abstract

There are thousands of machines equipped in the data center, each of the machines used to handle several users' request for the virtual machines. An optimum migration of virtual machines is essential for the improved utilization of resources. This paper sheds light on the energy aware migration of machines using the optimization technique. The study is used to implement the energy aware FA-VM migration for the efficient utilization of resources. The proposed study further compared with the existing techniques for superiority. The performance metrics such as SLA has been improved by 11%, energy consumption 29% and Number of VM migrations by 2.9% in comparison to existing techniques.

Keywords: VM migration, FA, Cloud datacenter, Physical Machines

1. Introduction

Cloud Computing plays a paramount role in providing various resources and services to their consumers on demand. The concept of virtualization has significant impact as the prescribed environment involves placement of virtual machines (VMs) on a single physical machine (PM) [Ibrahim et al. 2020]. In the actual context the services offered using a single operating system in which hardware platform system has been used for the operation of machines. Furthermore, the utilization of services in the virtual environment also minimises the idletime of the various PM's, and thus, prevent the under inflation ratio of the various resources. Furthermore, minimum use of power and maximum use of the hardware needed for the operation of machines. This benefits the data centre by cutting down the extra demand of the energy and thus, reduction in energy demand as per the Information and Communication Technology (ICT). The main is fact in the existing scenario in which rise in use of resources and energy crisis minimizes due to efficient utilization. The increase in energy consumption using Google, IBM and other similar multi-national corporations, in which resources have been provided using the datacenter's with their perquisite requirement as illustrated in Fig.1.

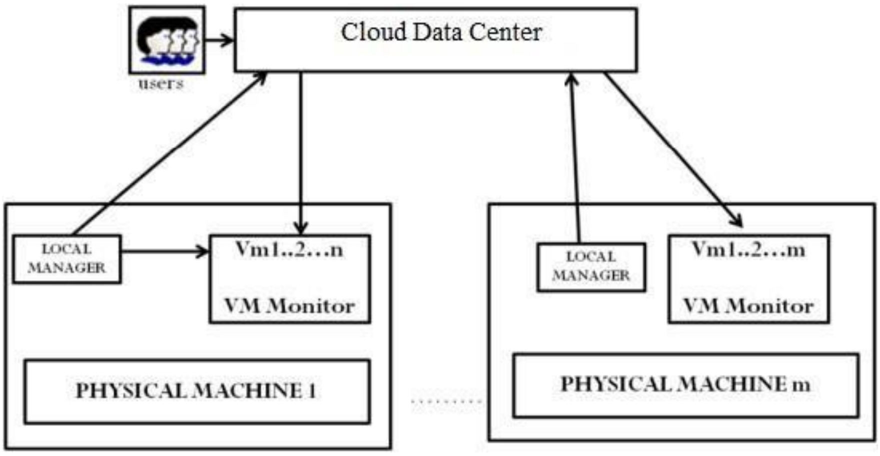

Fig. 1. Communication using Data centres for VM placement

Additionally, there are thousands of servers, interconnected devices and switches equipped in the data centres in which massive energy has been consumed. Moreover, operational cost is also very high and there is a massive increase in carbon dioxide emission into the global environment. Despite, cooling equipment has been used in controlling the heat produced by the devices, and it can be handled in a frequent manner. In the literature, several studies have shown that some of the servers were in the idle state and thus, consume 70% of energy which is at the peak demand. Therefore it is vital to analyse that running the servers with the less workload, there is a need of evaluating the methods that can be used to detect and determine the states of the idle machines. It is not in the field of local domain but also in the field of physical domain and thus, it is difficult to maintain the server's consuming low energy. Therefore, there is a need to reduce the energy consumption and it is a significant challenge for the practitioners in the cloud computing environment.

Specifically, the fact that virtualization and unified technology, there is a need of migration of virtual machines in which energy consumption has been reduced in a dramatically manner. The design patterns and using the resources has much attracted the attention of practitionersin the past. Beloglazov et al. developed an efficient energy conservation method in which allocation of VM's had been done by answering these questions:-

- When should the VM have been migrated?
- Which VM's need to be migrated?
- Where the VM's has been migrated?

Generally, the answering to these questions genuinely show the emergence of cloud computing and enabled technology. In the support of fit factors, the need of migration that runs the VM without any downtime and thus heavy loaded nodes are relieved the less loaded nodes. This is helpful not only to manage the machines but also minimise the consumption of energy revamping the improvement in node utilisation that results adjustment of distribution of work and thus, there is a less workload due to efficient distribution. Considering the VM migration, there are static migration in which migration has been done from one PM to other while operation of VM is halted and dynamic migration also stated as online migration whichplace the VM from one PM to another to ensure that the operation of VM's was running at a normal pace. There is not any noticeable impact as it allows the administrator to upgrade the operation of servers without affecting the usage of normal user. In the earlier processes, source host had been used to operate the VM. Whenever the migration process reaches apoint in which the remote host has all of the facilities required to operate the VM platform,the source host transmits power to the remote host after such a brief handover, and the VM framework continues to operate on the destination server. Since the switchover time is too short and the consumer does not notice the technical glitch, the migration procedure for the VM function is invisible to the client. Dynamic migration is appropriate in cases when VM accessibility is critical.

The main contribution of this paper is to develop an efficient VM migration framework using the optimization technique. The proposed method includes the use of MBFD algorithm for the best fitting of machines and then further optimized using the Firefly optimization algorithm. The proposed study ensures the efficient migration of VM's with minimum usage of energy consumption, and lesser number of service level agreements.

The paper is structured as follows: The paper is introduced in section 1 followed by the description of migration techniques in section 2. The research methodology is described in Section 3 which is follows by discussion on results in section 4. Finally, paper is ended in section 5 using a valid conclusion.

2. Related Work

In 2015, Xiong Fu and Chen Zhou develop a novel technique in selection policy for the VM had been developed. There are certain factors had been taken into account such as utilization of resources, migration time, violations of service level, selection policy and less consumption of power. The author's aimed to determine the correlation coefficient for the computation of target host.

Aryania et al. 2018 had been proposed the migration model considering the most important elements that was overlooked by traditional techniques. It dramatically limits the number of migrations and active PM's, resulting in a decrease in data centre total energy usage. The suggested methodology beats the state-of-the-art VM migration algorithm in terms of number of migrations, PMs state of idle, violations of service level, and consumption of power in simulations on a stochastic demand in various circumstances.

Soltanshahi et al. 2019 proposed a novel technique using the Krill heard optimization algorithm. Additionally, cloud technology infrastructures must deliver a good QoS to their users and, as a result, must be able to deal with power outages. VM placement to hardware platforms that is optimal conserves energy and enables for slightly elevated services. The Krill Herd method, which is the best collaborative algorithm published recently, was used in this research to suggest a revolutionary strategy for allocating VM to PM in cloud computing environment. The performance was evaluated using the CloudSim simulator, and the results indicate a 35% reduction in energy use.

Qin et al. 2019, the authors proposed the VM Scheduling system, which includes datagathering and workflow scheduling in this research. The energy efficiency and characteristicsof each machine are first determined in the proposed framework by running specific CPU intensive, memory-intensive, and hybrid evaluations. Thus energy efficient characteristics, servers will be labelled and classed based on their liking for various user requests. Themethod was next do workload categorization for each VM by tracing and tracking resource consumption, such as CPU memory utilization, and internet, to identify whether the burden iscomputing intense, memory-intensive, or a combination of both. Finally, the proposed method assigns VMs to multiple servers on the activity type of the VM and energy- efficient preferences of the server.

Dinesh et al. 2019 proposed a method for the placement of VMs. The authors presented a hybrid discrete PSO as well as a novel VM selection algorithm for optimising the current appropriation based on utilisation, network bandwidth, and virtual machine size. Practitioners observed through simulations that the suggested strategy not only minimizes power in comparison to other approaches, but also reduces SLA violations.

Abohamama, and Hamouda 2020, the authors worked on considering the previous enhanced Genetic Algorithm (GA) and a multivariate resource-aware Best Fit (BF) allocation technique, a hybrid VMP algorithm had been developed. The suggested VMP method seeks to reduce cloud infrastructure energy usage by reducing the number of operational web servers VMs. Furthermore, the proposed VMP method aims to ensure balanced use of active server' multifunctional capabilities (CPU, RAM, and Bandwidth),reducing wastage of resources. Hypothesis tests were used to validate the performance analysis of both hybrid methods. The collected results tested that utilising several typical datasets to determine the performance measure.

Jiang et al. 2021, the authors in this research provides a VMM approach considering the three-way decision (VMM-3WD) model to reduce host energy by cloud and usage while taking into account VMM correlation factor. The initial step in the technique is to categorise nodes such as overloaded, moderate traffic, or load balance, depending on their imperative factors. Then, for each of these categories of cloud service providers, separate migration procedures had been designed. The method, in particular, migrates VM fromheavy loaded hosts to typical less loaded hosts. The method then produces two benchmarks tosplit overburdened hosts into three categories: enormously overwhelmed, substantially overfilled, and gently overloaded. The choice to migrate VMs at all phases is made with the purpose of lowering the network's consumption of energy during the process of migration.

Singh and Singh 2021, A VM migration technique based on (FFO) had been presented, which assigns jobs to physical computers in cloud data centers. It aims to transfer heavily loaded VMs from one PM to another with the least amount of energy usage possible. The simulation results reveal that the FFO approach which is performed in the CloudSim simulator, saves up to 14% more hosts than the First Fit Decreasing (FFD) method and about 8% which are more than ACO in terms of number of servers saved (ACO). It lowered energy usage by 13% compared to FFD and 8% compared to ACO, resulting in 52% fewer migrations compared to FFD and 45% fewer migrations opposed to ACO.

Balaji et al. 2021, the suggested work's main goal was to use the modified discrete FFA for power consumption that was organized the VM as densely as feasible in a small multiple servers. The suggested algorithm will accurately search a broad search space for a data centre deployment that consumes the least amount of power. The proposed approach had been used to put VM's in IaaS clouds in varying combinations, and the performance is evaluated to those of the GA, demonstrating that PSO is superior.

3. Research Methodology

The proposed methodology is based on the migration of VM from one PM to other PM based on the utilization of resources. The study includes the optimization of VM migration using the FA.

3.1 Firefly Algorithm (FA)

FA has been developed by Yang and Deb at Cambridge University in 2008. It is based on the working of flashing fireflies, and it is based on the three subsequent procedures:-

1. All the fireflies in the collection of group are unisex and individual firefly attracted to wards other considering the flashing characteristic.
2. The fireflies' attractiveness is directly proportional to the amount of light or brightness level not considering the sex. An increase in distance from one firefly to other one decreases the brightness level.
3. The brightness level has been regulated by the objective function for optimization.

Thus, variation in brightness level (β) with distance (d) defined as follows:-

$$\beta = \beta_0 e^{-\gamma d^2} \qquad (1)$$

Where, β_0 is the level of attractiveness at d=0. The firefly movement (m) of a firefly is directly proportion to the attractiveness or brighter level (i) which is determined as follows:-

$$y_m^{t+1} = y_m^t + \beta_0 e^{-\gamma d_{mj}^2}(y_i^t - y_m^t) + \alpha_t \epsilon_m^t \qquad (2)$$

Where, α_t is the parameter used to control or manage the randomness and ϵ_m^t is a random number generated using the Gaussian distribution at time t. The second term in the equation 2 is based on the attraction and the third term is based on the randomization. In the given equation 2, $\beta_0 = 0$, it means a walk is simple and having random nature. On the other hand, $\gamma = 0$, the value reduces as per variant.

3.2 Energy efficient VM migration using FA

The prior work is related to the tasks scheduling and has been done earlier and the proposed model is resource aware utilization model as illustrated in Fig. 1.

The current work is based on the development of energy aware schedule decision model in which VM is migrated in an efficient manner. The current study includes the development of algorithm for efficient utilisation that provides resources to the consumers based on the different factors. This revamps the utilisation of resources and minimise the consumption of energy consumed by the cloud data centres without affecting the performance of the system. The energy saving has been also done by migrating the state of the nodes in an idle state to the sleep mode. Furthermore, energy efficient decisions can be taken based on the knowledge taken from the past for utilization of resources and consumption of energy. Therefore we can said that as there is an improvement in resources distribution by the server and also reduces the consumption of power and, thus there is a minimum dissipation of heat in the service centres. This ultimately contributes the green cloud computing.

Specifically, the main problem formulation constitutes the development of energy model under detailed work as explained in the given figure. The current work includes the development of energy efficient and migration of machines for the cloud data centres considering the characteristics of the Fireflies. This approach migrated the most heavily loaded VM from one state of active node that satisfies the threshold criteria or minimum criterion for the consumption of energy to the other active node that consumes the lessenergy. The proposed work is mainly divided into four different parts: (a) Source node is selected (b) VM selection based on the utilisation (c) destination node is selected based onthe criteria (d) Updating the distance. The description of these parts has been described as follows:-

(a) Source Node:

It is the main active node or the place from which migration of VMs has been taken place. Moreover, the active node is located at the least distance for the destination node andfollowing steps has been considered for this as follows:-

- Energy consumed by each node has been computed using the equation 3 and values are stored in the list.

$$EC_j = \frac{(\sum_{n=1}^{v}\sum_{p=1}^{u} CPU_{jpn})(\sum_{n=1}^{v}\sum_{p=1}^{u} MU_{jpn})}{Number\ of\ units\ for\ memory} \times t \qquad (3)$$

Equation 3 represents the consumption of energy by each node, v signifies the VMs operated on the jth node, and u is the tasks assigned to v number of VMs. CPU and MU represents the Central Processing Unit and Memory Unit for p jobs running in jth node. Store the computed values in a List EC.

- Brightness Index (BI):

Brightness index is directly proportional to the attraction level of the fireflies and has been modelled computing the BI value. BI value has been computed using the indexing function and sorted BI list arranged according to the utilization of energy and number of VM migrations. Computation of $BI_*6EC_{*,*}9$ for each node operated in an active state. VMmigration for each active node is computed using the following equation 4.

$$NVM_j = \sum_{n=1}^{v}\sum_{p=1}^{u} N.VM_{jpn} \qquad (4)$$

Equation 4 represents the computation of number of VM migrated from one place to other and $N.VM_{*pn}$ signifies the migration of p jobs running in n VMs on the j^{th} node.

The selected node has a potential source to migrate and must satisfy the minimum critera or threshold level for consumption of energy and controlled by computing the distance which must be least for minimum energy consumption. Thus, selection of node is based on the less distance and number of VMs migrated considering the source node. The distance has been computed using the Equation 5.

$$Distance\ (d) = Average(BI_{min}, BI_{max}) \qquad (5)$$

Where, $BI_{m)}$ and BI_{max} are the minimum and maximum values in the BI list.

Thus, selection of active node has been based on the value of EC closest to the above distance formula.

(b) VM selection based on the utilisation

The migration of VMs has been determined considering the source node and load has been computed for each VM using the Equation 6.Further, values are stored in the list and list is arranged from higher to lower values. The highest loaded value in the list has been moved to destination end.

$$Load_{jn} = \frac{\sum_{n=1}^{v} task_n}{\left(\frac{\sum_{n=1}^{v} CPU_{jn} \sum_{n=1}^{v} MU_{jn}}{Number\ of\ units\ for\ memory}\right) \times \Delta t} \qquad (6)$$

In the Equation 6, $task_n$ is the total number of tasks in the n^{th} VM on j^{th} node and $\frac{\sum_{n=1}^{v} CPU_{jn} \sum_{n=1}^{v} MU_{jn}}{Number\ of\ units\ for\ memory}$ is the consumption of power of the j^{th} node with change in time (t). Store the computed values in the list and arrange from higher to lower loaded VM.

(c) Discovering the Destination node

The destination node has been discovered based on the brightness level. The Fireflies characteristics based on the illumination level in which active node move towards the brighter one by identifying the brightness level. The node is said to be brightest having the minimum energy consumption and has been arranged accordingly.

(d) Updating the distance

After each iteration or simulation step, the value has been updated based on the brightness and distance, which is given in Equation 7.

$$(d)^{t=1} = (d)^{t} + \frac{\sum_{n=1}^{v} task_n}{\left(\frac{\sum_{n=1}^{v} CPU_{jn} \sum_{n=1}^{v} MU_{jn}}{Number\ of\ units\ for\ memory}\right) \times \Delta t} + \in \quad (7)$$

Equation 7 signifies the value of distance at time (t) and (t+1), and the second term signifies the load and ∈ is the distribution error. The Pseudo code of the proposed energy efficient FA- VM migration is as follows:-

Pseudo code 1: FA-VM migration algorithm

Input: Information related to scheduling of tasks in which set of tasks, energy consumption using nodes, and utilization of resource information
Output: Finding the best place for VM migration

1. Begin
2. S_N () // Source Node initiated
3. For each node do
4. Computation of Energy Consumption using equation 3.
5. EC [ ] ← $List\ of\ Energy\ consumed\ by\ nodes$
6. Computation of number of VM migrations using equation 4.
7. NVM [ ] ← $Numberof\ VM\ migartions$
8. For next node do
9. Computation of Brightness Index.
10. [ ] ← $Brightness\ Index\ value$
11. Sort the list BI[ ] as per EC [ ] values in an ascending manner
12. Computation of Distance using Equation 5.
13. Find the active node having EC value near to the BI value as per distance formula.
14. For next node do
15. Compute the value of load using the Equation (6)
16. L[ ] ← $Load\ value$
17. Sorted the list in descending order.
18. At the destination node, place the first element from the sorted BI [] list.
19. Update the value of distance using Equation 7.

4. Results and Discussion

The performance of the proposed FA-VM migration model has been evaluated consideringthe number of VM migrations, Energy consumption, and number of SLA violations.

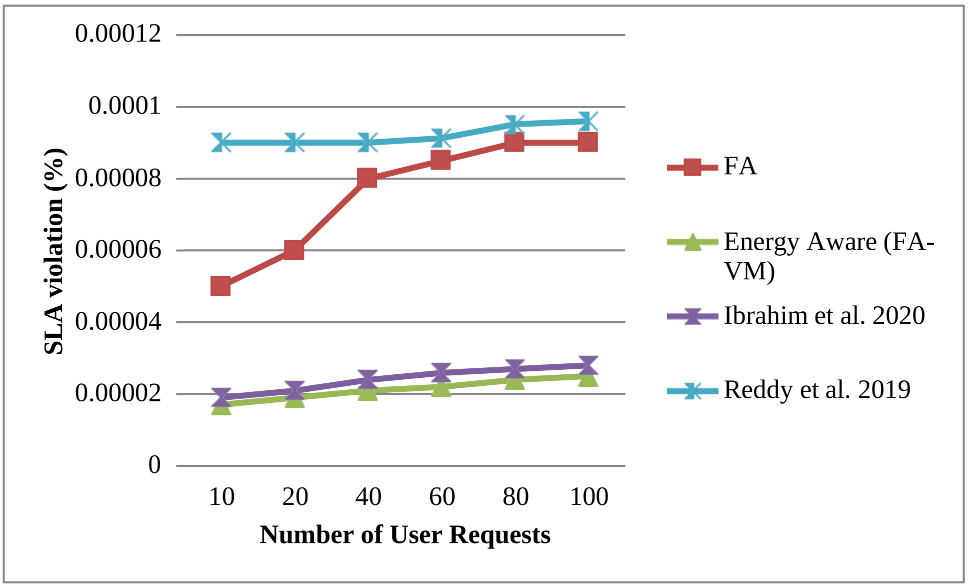

Fig. 3. Comparison using existing techniques for SLA violation

Fig. 3 represents the comparative analysis of the proposed approach with the existing technique for SLA violation. The outcomes show that average values of the proposed energy aware FA is about 0.00002 while that of existing technique PSO Ibrahim et al. 2019 is 0.000024. The average SLA using the existing technique id 0.00009 [Reddy et al. 2019] and FA is 0.000075. Thus, proposed approach has been improved by 11.7% in comparison to PSO.

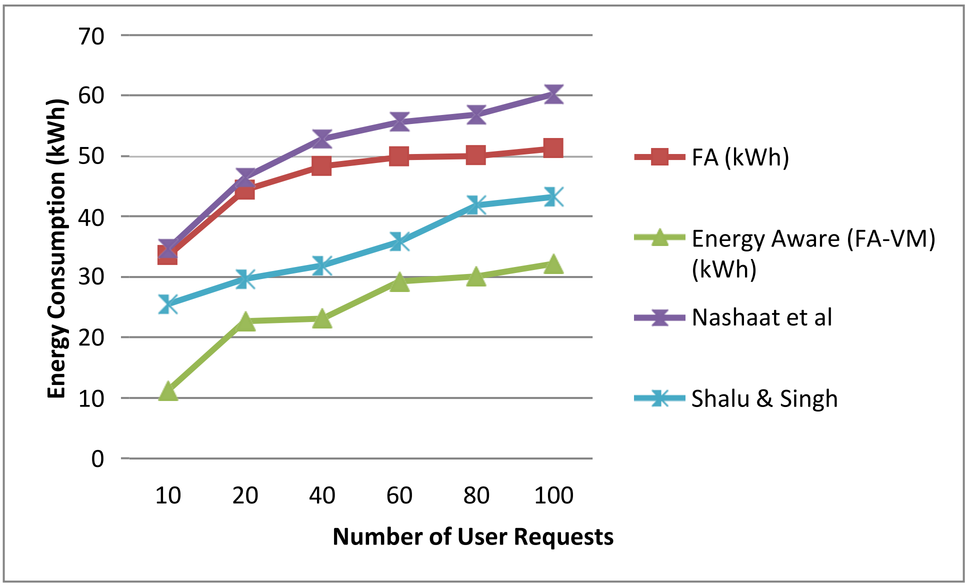

Fig. 4. Comparison using existing techniques for Energy Consumption

Fig. 4 represents the comparative analysis of the proposed approach with the existing technique for energy consumption. The outcomes show that average values of the proposed energy aware FA is about 24.75 kWh while that of existing technique Nashaat et al. is 51.24. The average SLA using the existing technique is 34.64 kWh [Shalu and Singh] and FA is 46.19 kWh. Thus, proposed approach has been improved by 28% in comparison to Nashaat et al.

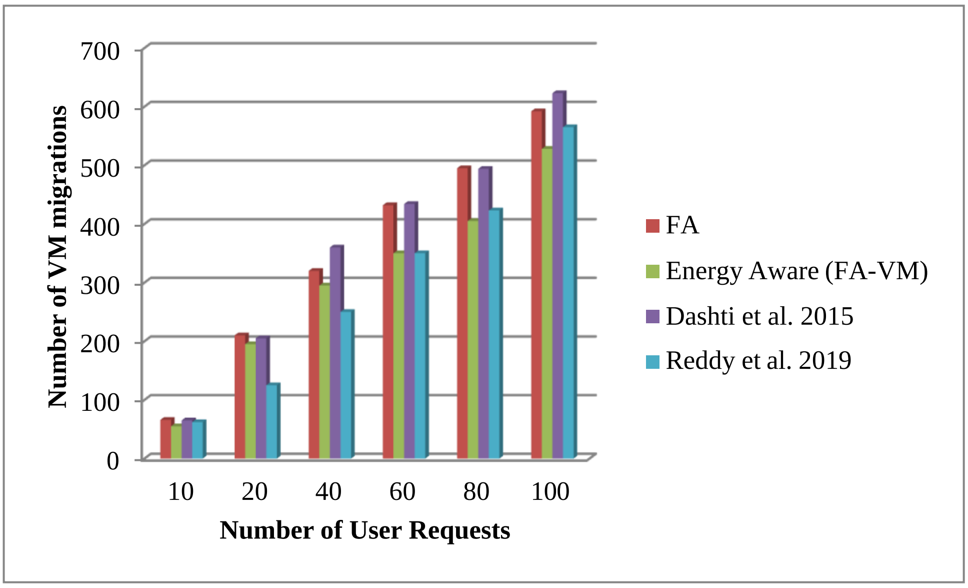

Fig. 5. Comparison using existing techniques for VM migrations

Fig. 5 represents the comparative analysis of the proposed approach with the existing technique for the number of VM migrations. The outcomes show that average values of the proposed energy aware FA is about 305 while that of existing technique Dashti et al. 2015 is 363. The average migrations using the existing technique is 296 [Reddy et al. 2019] and FA is 352. Thus, proposed approach has been improved by 2.8 % in comparison to Reddy et al. 2019

4. Conclusion

The minimum use of power and maximum use of the hardware are the main concerns of the cloud centre researchers. This benefits the data centre by cutting down the extra demand of the energy and thus, reduction in energy demand. This paper proposed an energy aware optimization technique based migration of VM concerning minimum use of energy and efficient use of resources. The experimental results are based on the measurement of performance metrics which are further compared with the existing techniques. The performance metrics such as energy consumption using the proposed approach is 24.75 kWh which is least in comparison to existing techniques.

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