Green Cloud: A Pocket-Level Simulator with On-Demand Protocol for Energy-Aware Cloud Data Centers

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Abstract: ***Energy efficiency is an important aspect of Green Cloud and the Cloud data centers have huge impacts on it. Research scholars are seeking to find effective solutions to make data centers, reduce power consumption while keeping the desired quality of service or service level objectives such as workloads and connectivity. As the Cloud computing contributes in two ways. First, it plays a significant role in the reduction of data center energy consumption costs, and thus helps to develop a strong and competitive Cloud computing industry. Second, consumers are increasingly becoming conscious about the environment. This indicates that the energy utilized by computation and communication of Cloud data center, contributes a considerable slice of data center operational costs. Also, the Cloud data centers not only consume huge amount of energy but are also very complex in the performance. In the proposed system, the simulator is designed to capture details of the energy consumed by data center components as well as the pocket-level communication patterns in realistic setups. Here, we introduce the Ad-Hoc On-Demand or Reactive protocol to improve the performance of connectivity, workload management and energy efficiency of Cloud data centers. Hence, the protocol with aggregation method in order to reduce message replies in the network and energy consumption while transaction to increase the quick connection establishment. The results show that the discovery success rate and the message reduction to minimizing the energy consumption and boost the overall performance of Cloud data centers.***

Keywords: AODV Protocol, Cloud service with Protocol, Energy-aware Cloud, Energy efficiency, Data center energy consumption, Green data centers.

1. Introduction

Cloud Computing is a technology of centralized internetworking remote servers to maintain applications and data. It allows us to use applications without installation and access their personal files by centralizing data storage, bandwidth and processing at any computer with internet. It provides [1] the facility to access shared resources and common infrastructure, contributes services on demand over the network to perform operations that meet changing business needs. The end users do not have the location awareness of physical resources and devices being accessed. It also provides facilities for users to develop manage and set up their applications on the cloud environment, which entails virtualization of resources that maintains and manages itself. Cloud computing is segmented in three types are application, connectivity and storage [2]. Each segment serves a different purpose and offers different products for businesses and individuals around the world. The applications of cloud computing are practically limitless and work on a cloud computing system. Cloud Connectivity and Data center networking services deliver consistent application performance and enable you to connect to cloud service providers. Cloud storage is called as Cloud data centers; it is a model of networked enterprise storage where data is stored in virtualized pools of storage which are generally hosted by third parties.

Green Cloud represents the Cloud data center's energy efficiency and makes it greener by limiting the energy usage of data centers while performing tasks in it. It relies on two main components, Green Cloud offers and Carbon Emission Directory, which keeps track of energy efficiency of each Cloud provider and user, also give incentive to Cloud providers to make their service "Green". It acts like a new middleware that manages the selection of the greenest Cloud provider to serve the user's request. From user side, the Green middleware plays a crucial role in monitoring and selecting the Cloud services based on the user Quality of Service needs, and ensuring less carbon emission for serving a user. Most of efforts for sustainability of Cloud computing have missed the network contribution. Here, we focused on Cloud data centers that are becoming increasingly popular for the provisioning of computing resources. The operational expenses and cost of data centers have skyrocketed with the increase in computing capacity [4].

Energy consumption is a growing concern for data centers operators. Energy usage in a cloud computing model has received more attention through the use of large storage units and shared servers, cloud computing can recommend energy savings in the provision of computing and storage services, for the most part if the end user migrates toward the use of a computer or a terminal of lower capability and lower energy utilization. Simultaneously cloud leads to increases in network traffic and the associated network energy utilization. The issue of energy consumption in information technology equipment has been receiving increasing attention in recent years and there is growing recognition of the need to manage energy consumption across the entire information and communications technology (ICT) sector

[12], [13]. The management of power consumption in data centers has led to a number of substantial improvements in energy efficiency [16]. The goal of Green Cloud architecture is to make Cloud green from both user and provider's perspective by concentrating on energy usage of both sides.

Here, we discussed about the Ad-Hoc network which is a group of wireless mobile computers (or nodes), in which nodes cooperate by forwarding packets for each other to allow them to communicate beyond direct wireless transmission range and it is an infrastructure less network. The existing infrastructure does not meet application requirements for reasons such as security or cost [17]. These networks inherit the traditional problems such as power control, bandwidth optimization and transmission quality enhancement of wireless and mobile communications [18]. The primary goal of such an ad hoc network routing protocol is correct and efficient route establishment between a pair of nodes so that messages may be delivered in a timely manner. Various approaches and protocols have been proposed to address ad-hoc networks must discover such paths and maintain connectivity when links in these paths break due to effects such as node motion, radio propagation, or wireless interference. In recent years, a number of new multicast protocols of different styles have been proposed for ad-hoc networks. Here, we focused on one of the ad hoc Reactive protocol is Ad Hoc On-Demand Distance Vector(AODV) protocol for our proposed work.

AODV builds routes using a route request/route reply query cycle [19]. AODV maintains routes for as long as the route is active. The advantage of AODV is that it creates no extra traffic for communication along existing links. It is simple and needs less memory or calculation, but requires more time to establish an initial (first-time) connection. Here the route is heavier than some other approaches. This protocol is having routes established on demand and the connection setup delay is lower.

In this proposed work, we are introducing the AODV protocol for Green Cloud. Here, the protocol used in between the user node and the Cloud data center. There are no intermediates in between the user node and the data centers. Main consideration is to improve the energy consumption and boost the performance of Cloud data centers by concentrating on connectivity to balance the memory, bandwidth and time. It organized with NS2 Simulator to implement this concept. Although this process is to motivate the Green Cloud mean that the energy-aware data centers, also applicable to the user node and the result also apply to all wireless networks.

The rest of paper is structured as follows. Section 2 presents related works. In Section 3 give a brief overview of the Simulation environment. We discuss the Methodologies which are used in this proposed work for Green Cloud in Section 4, and evaluation of results in Section 5. In Section 6, we discussed the result which is evaluated in Section 5. Finally, we conclude the paper with discussions in Section 7.

2. Related Work

Cloud computing data centers are becoming increasingly popular for the provisioning of computing resources. Many surveys designate that the energy utilized by computing and communication units within a data center contributes to a considerable slice of the data center operational costs. The cost and operating expenses of data centers have skyrocketed with the increase in computing capacity. In [26], Dzmitry Kliazovich et al introduce the simulation environment for Green Cloud and used the Dynamic Voltage Frequency Scaling or Dynamic Shut-down Techniques at both the component and system levels. It reduces the costs of operating the IT equipment. Also, cooling and increase server density enlarging the capacity of existing data center facilities, but it is not centralized and scheduled. In [21], Sisay T. Arzo et al emphases the role of communication fabric and presents a scheduling solution, named e-STAB for Cloud computing. Here, the scheduling approach for a cloud computing system that optimizes the energy consumption of the data center IT equipment while providing load balancing of traffic flowing within the data center network. Also, it reduces congestion-related packet losses and communication-related delays. The validation results, obtained from the Green Cloud simulator, underline the benefits and efficiency of the proposed scheduling methodology. Still, the validation results not increases the energy consumption as expected. In [30], Janine Kniess et al propose a service discovery protocol that applies a data aggregation scheme in intermediate nodes to reduce messages replies in these networks. Energy efficiency is an important aspect of green computing in order to achieve green computing in service discovery protocols for MANETs. They investigate energy efficiency mechanisms able to reduce waste of channel bandwidth and energy by preventing collisions and interferences. In this approach, the main drawback is it is not good with network scalability and the period of time to keep the message stored in a node.

In [22], Liang Liu et al present the Green Cloud architecture, which aims to enable live virtual machine migration, comprehensive online-monitoring and virtual machine placement optimization. Consolidate workload and achieve significant energy saving for cloud computing environment and guarantees the real-time performance for many performance-sensitive applications. Here, the Green Cloud not met the web service, Online Transaction Processing (OLTP), and the human resource management for real business services. In [24], Yuan Yao et al focus on a stochastic optimization based approach to make distributed routing and server management decisions in the context of large-scale distributed data centers, which offers considerable aspect for exploring power cost reductions. This approach has provable performance bounds and is especially effective in reducing power cost when handling delay tolerant workloads. Also it is robust to workload estimation errors and can result in significant power consumption reductions. But, it only focuses on distributed data centers.

In [20], Rajkumar Buyya et al present vision, challenges, and architectural elements for energy-efficient management of Cloud computing environments. Here, enabling energy-efficient resource allocation and boost data center energy efficiency and performance. Like [20], in [23], Samee Ullah Khan et al underlines the role of communication fabric in data center energy consumption and presents a scheduling approach that combines energy efficiency and network awareness, termed Data center Energy-Efficient (DENS). The DENS methodology aims to achieve the balance between individual job's performance, Quality-of-Service requirements, traffic demands, and energy consumed by the data center. Data intensive jobs require low computational load, but produce heavy data streams directed out of the data center as well as to the neighboring nodes. Such data intensive jobs are typically produced by popular video sharing or geographical information services. But, it work with low computational load, but produce heavy data streams directed to the end- users.

In [28], Antti P. Miettinen et al says, the Cloud computing has the potential to save mobile client energy but the savings from off loading the computation need to exceed the energy cost of the additional communication. It improvises the energy consumption without affecting end-to-end chain of transmission, but the decision making cannot be restricted to design time only.

In [29], Jayant Baliga et al present an analysis of energy consumption in cloud computing. It considers public and private clouds, and includes energy utilization in switching and transmission as well as data processing and data storage. Serve a very large number of users are expected to be able to fully benefit from achieving high levels of utilization and high levels of virtualization, leading to low per-user energy consumption. Because of load balancing the energy savings from cloud storage are minimal. In [25], Gong Chen et al develop the power saving techniques for connection services and in [27], Yiyu Chen et al analyzed the growing cost of tuning and managing computer systems is leading to out-sourcing of commercial services to hosting centers. It provision thousands of dense servers within a relatively small real-estate in order to host the applications/services of different customers who may have been assured by a service-level agreement (SLA) but it is not time consuming.

In contrast to previous work, we have discussed the clear view of energy efficiency in Cloud computing environment. As per this review the Cloud data center still not reached the maximum level of energy consumption and the better performance or service. This proposed system is to provide, more consumed energy aware datacenter and increase the performance of data center when compare with existing works. Moreover, we concentrated on the connectivity related issued which can be overcome by AODV protocol to improve the overall performance of data centers.

3. Simulation Environment

The simulation environment for energy-aware cloud computing data centers along with the workload distribution. The simulator is to capture details of the energy consumed by data center as well as packet-level communication patterns in realistic setups. It offers a detailed fine-grained modeling of the energy consumed by the data center network switches, computing servers and communication links. Also, it is used to develop novel solutions in monitoring, workload scheduling, resource allocation as well as optimization of communication protocols and network infrastructures. However, it simulates existing data centers as well as help to design future data center facilities.

The Network Simulator (NS2) is an object oriented simulator, written using C++ language, with an Object-oriented Tool command language (OTcl) interpreter as a front-end. The simulator supports C++ class hierarchy and OTcl interpreter class hierarchy. These hierarchies are closely related to each other from the user's perspective. The root of the interpreter hierarchy is the class Tcl Object. The NS components are mostly compound network components. Figure 3.1 shows a partial OTcl class hierarchy of NS, which helps to understand the basic network components.

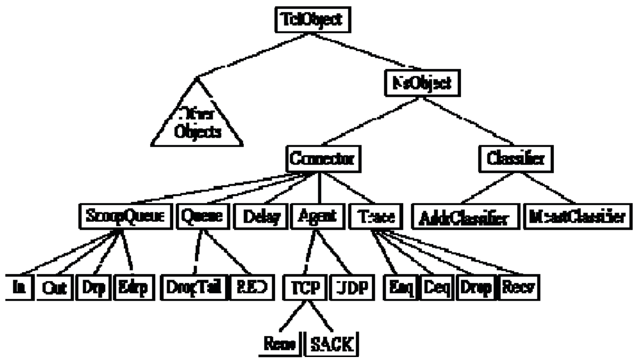


Figure 3.1: Class Hierarchy

4. Methodology

In this proposed work, introduces the AODV protocol which is efficient to track and manage the traffic in Green Cloud. Exploiting the Green Cloud architecture with this protocol provides the improvised energy efficiency and performance of Cloud data centers. Green Cloud architecture, which aims to reduce data center power consumption, while guarantee the performance from user's perspective. Here, we implement the same methodology the Cloud data center and also implement the AODV protocol for connection establishment between the user and Cloud data centers.

The contributions of this method are:

a. Green Cloud architecture enables comprehensive online-monitoring, live virtual machine migration and Virtual Machine (VM) placement optimization.
b. Green Cloud is to automatically make the scheduling decision on dynamically migrating/consolidating VMs among physical servers to meet the workload requirements meanwhile saving energy and specially for performance-sensitive.
c. A Green Cloud data center is conventional hierarchical network infrastructure often becomes a bottleneck due to the physical and cost-driven limitations of the used networking equipment.
d. Green cloud uses Equal Cost Multi-Path (ECMP) routing is used as a load balancing technology to optimize data flows across path. It applies load balancing on TCP and UDP packets on a per-flow basis using express hashing techniques.
e. Line Aggregation Groups (LAGs), which allow a network

client to address several links and network ports with a single Medium Access Control (MAC) address to increase link capacities its usage has several fundamental drawbacks that limit network flexibility and performance (a) access, (b) aggregation, and (c) core layers.

f. The number of core switches and capacity of the core links defines the maximum network bandwidth allocated per computing server.

g. Power management is Dynamic Voltage and Frequency Scaling (DVFS) it introduces a tradeoff between computing performance and the energy consumed by the server. The DVFS is based on switching power in a chip decreases proportionally to V2 • f, where V is voltage, and f is the switching frequency.

$$P= p_{fixed} + p_f . f^3$$

We combine the green with Location aware Discovery service for service selection mechanism that applies.

h. A data aggregation scheme is to filter the responses aiming to reduce the exceeding replies and save energy.

i. A service discovery mechanism that adjusts a search area for each individual request. Likewise the service invocation mechanism.

j. That specifies how the service providers will be accessed and used by the requester node. A node in the network needs information about service providers and sends discovery messages. The LADS mechanism limits the search diameter Ri, on the basis of the maximum speed that a node/data center can reach, vmax (each type of resource knows this value), and the maximum response time for one request, tmax. Using Ri, this mechanism prevents unnecessary request and reply transmissions in the network.

k. The diameter Ri is given by the equation:

$$R_i <= V_{max} * T_{max}$$

l. The energy consumed by the data center gets delivered to the computing servers directly. It can be classified (a) computing energy, (b) communicational energy, and (c) the energy component related to the physical infrastructure of a data center. The data center can be defined in terms of the performance delivered per watt, which may be quantified by the following two metrics: (a) Power Usage Effectiveness (PUE) and (b) Data Center Infrastructure Efficiency (DCiE).

4.1 Location Aware Service Selection (LASS)

The result of the discovery process, multiple providers can respond to a service request. The LASS mechanism takes into account such aspects as the requester node's geographic location, the maximum response time to attend one request, the speed that the service provider moves, and the number of service providers desired to select and discard answers. The aim is to reduce the message reply transmissions from the network. LASS work as follows. Suppose that node k (intermediate node) receives the reply message from one of its neighbors, for instance, node m. Then, node k starts a timer, named intermediate, with the function of storing replies.

4.2 LASS Data Fusion Scheme

When an intermediate node receives one response, the intermediate node starts intermediate. If the maximum number of responses that meet the requests profile is reached before intermediate expires, the intermediate node aggregates these responses and sends only one response to the requester node. After this step, intermediate is canceled by the intermediate node. Others responses max provider received are discarded. If the intermediate node receives a response directly from a provider, the response was not aggregated. In this case, while the maximum number of responses is not reached, the intermediate node stores responses. The LASS algorithm works if the intermediate node receives a response from another intermediary node.

The number of stored responses plus the number of aggregated responses may not exceed. In order to solve this problem, the LASS algorithm updates the stored responses on the condition that the aggregated responses have better quality than the stored responses. The LASS mechanism is presented in Algorithm 1. It is noteworthy that the repeated answers (already treated by a particular provider) are discarded.

4.3 Service Invocation Mechanism

The service invocation mechanism operates after the selection service phase and establishes rules for access and use of the providers already selected. In the service invocation phase, requesters and providers verify the viability of the attendance and the providers physically move to the place where the service is required. When a provider informs that it is available go to the place where the service is required it begins to move toward the requester. However, the confirmation message may be lost. In order to attend this fault, we considered that if the provider receives a discovery message of the same requester, the provider restarts the process and sends a reply message (message reply) to the requester. Also, in this case, the provider can respond to other requesters. A provider is only allocated to a requester after sending the confirmation message.

5. Evaluation of Research

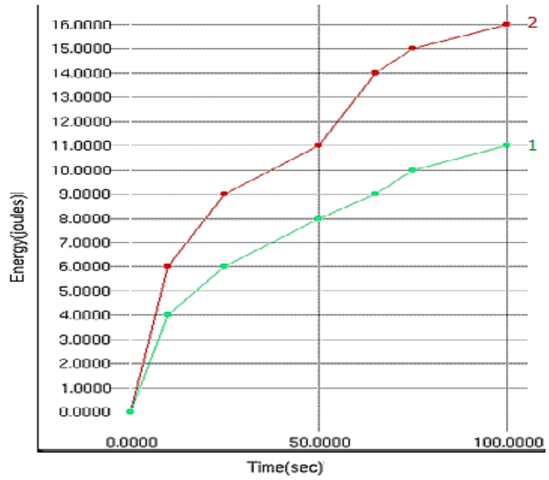
In this section, we evaluate Cloud data centers performances such as the energy efficiency, packet delivery and delay with the existing system with the simulation environment.

5.1 Energy Consumption

Energy Consumption (EC) measures the energy usage while transferring data in both node and the data center even the node or data center in the ideal, sleep, transmit and receive the packets from both ends. It calculated in Joules and it expressed as,

$$EC = \frac{\text{Average Energy consumed on each node (Node may be in ideal,sleep,transmit and receive)}}{\text{Total energy consumed}}$$

As per the comparison, the simulator provides the graph which is represent the increased result of this proposed work.



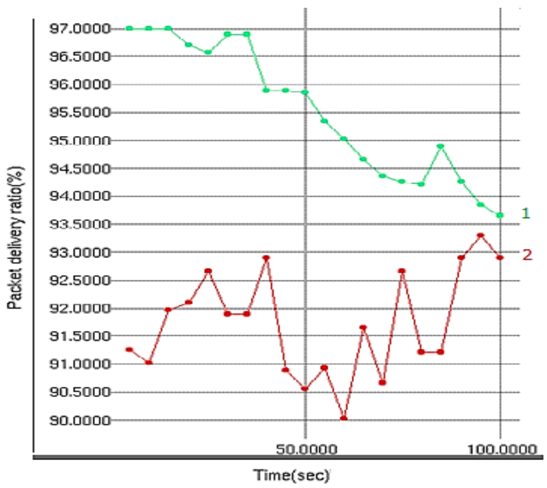
Graph 5.1: Time vs Energy consumption

In the Graph 5.1, 1 represents the energy consumption result of proposed work and 2 represents the result of existing work. The energy usage is reduced when compare with the existing work.

5.2 Packet Delivery Ratio

Packet delivery ratio (PDR) measures the percentage of data packets generated by nodes/data center that are successfully delivered. It measures in percentage and it expressed as,

$$PDR = \frac{\text{Total no.of data packets received}}{\text{Total no.of data packets sent}} \times 100$$



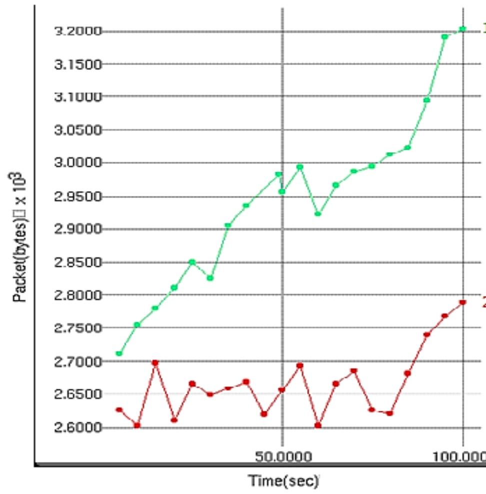
Graph 5.2: Time vs Packet delivery ratio

In the Graph 5.2, 1 represents the packet delivery ratio result of proposed work and 2 represents the result of existing work. The packet delivery ratio is increased when compare with the existing work.

5.3 Packet Received

Packet Received (PR) measures the number of packets received while both the end enabled and transferring data. The result is in numbers and it expressed as,

PR = **Number of packets received**



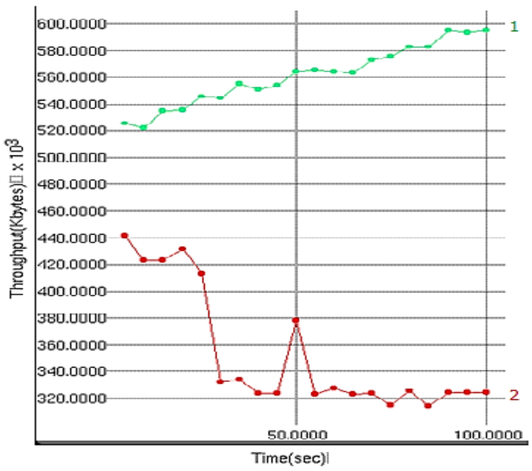
Graph 5.3: Time vs Packet received

In the Graph 5.3, 1 represents the packets received per second in both proposed work and 2 existing work. The number of packet received in seconds/minutes is increased when compare with the existing work.

5.4 Throughput

Throughput (T) defined as the number of packed at destination side at a particular time. It means the accuracy of packets which is received. It measured in bytes and it expressed as,

$$T = \frac{\text{Number of data packets received}}{\text{Time}}$$



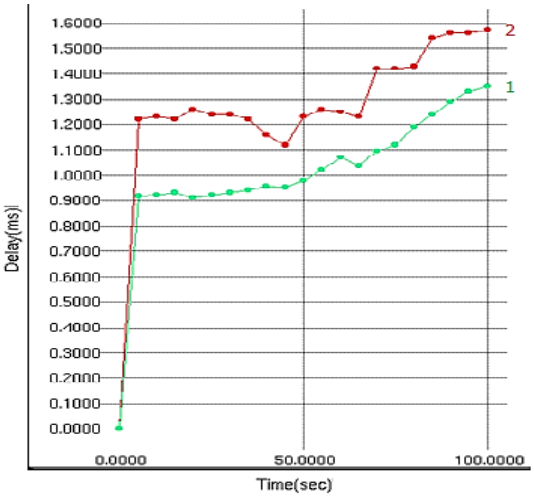
Graph 5.4: Time vs Throughput

In the Graph 5.4, 1 represents the accuracy of packet delivery result in both proposed work and 2 existing work. The accuracy of packet delivery measured in bytes. Here the accuracy is high when compare with the existing work.

5.5 End-to-end Latency

End-to-end Latency (EL) measures the average time taken by the node/datacenter before transferring the packets also called the preparation time to transfer data. The delay time calculated in seconds/microseconds and it is expressed as,

$$EL = \frac{\text{Inter arrival of two packet}}{\text{Total data packets received}}$$



Graph 5.5: Time vs End-to-end Delay

In the Graph 5.5, 1 represents the result of delay time which is taken by the node or the data center before transferring the packets/data in both proposed work and 2 existing work. Here the delay time is reduced when compare with the existing work.

As per the above evaluation, the Table represents the accurate result which we got after implementation in simulation environment for Green Cloud. In the next section we have discussed the result with accurate value which is given in the table.

Table 5.1: Comparison of result

	Time(Sec)	*Existing*	*Proposed*	*Difference*
Energy Consumption	100	16	10	6 Joules
Packet Delivery Ratio	100	92	93	1%
Packet Received	100	2789	3204	415 packets
Throughput	100	0. 2789	0. 3204	0.415 bytes
End-to-end Delay	100	1.57	1.35	0.22 sec

6. Discussion

In this section, we discuss the results of the Cloud data center's performance with the existing system. Here, the Table represents the comparison result of Cloud data center's energy consumption rate and performance with the time of 100 seconds. First, the Energy consumption of the Cloud data centers. The result represents the data centers energy usage. Here, we minimize the energy usage by introducing the protocol for connectivity with the Green Cloud concept. The result represents, the energy saved up to 6 Joules when compared with the existing work. The main objective of this research is to reduce the energy usage of Cloud data centers and the result archived the same.

Second, the packet delivery ratio defined in both user node and the Cloud data center. Here, the result represents the packet delivery ratio of data centers in percentage. The data center's packet delivery ratio is increased as 1%. Third, the packet received by the node and the data center is measured in numbers. We have fixed the packet size and transferred from both the ends. The result represents the packets received by the data center is leads 415 packets than the existing work. Fourth, we discussing about the accuracy, it is nothing but if any packet loss the accuracy will be reduced. Here, the result shows the accuracy is increased. Fifth, the delay time, which taken by the user node or the data center to transmit the data/packets to each other. The result shows that the delay time reduced as expected. The overall performance is considered with packet transmission rate and the delay time is increased. Likewise the energy consumption of data center also increased due to the implementation of new concepts with Green Cloud.

7. Conclusion and Future Work

The proposed system uses simulator to capture the details of energy consumed by Cloud data center components as well as packet-level communication patterns in realistic setups. The protocol AODV is to improve the energy efficiency of both data center and the user node performance as well as the performance of Cloud data centers. Here, the Ad-Hoc protocol emphasize the aggregation method in order to reduce message replies in the network to lead the traffic reduction while transformation of packets. It improves the energy efficiency, increases the accuracy of packet delivery, reducing the communication-related delays and congestion-related packet losses. The results confirm that the discovery success rate and the message reduction to increase the performance of Cloud data centers and improve the energy efficiency.

Future work focus on Ad-Hoc configurations and factors such as overhead, security and reliability will be considered. By implementing the concepts in Green Cloud infrastructure the energy efficiency and performance of data center increases. The other parameters such as jitter and bandwidth can also be taken to improve the performance even better.

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