Implementation of Energy Efficiency Cloud Data Center Architecture Model using Green Cloud Simulator in National Data Center of Bangladesh

Rabab Khan Rongon

A Thesis in the Partial Fulfillment of the Requirements

for the Award of Bachelor of Computer Science and Engineering (BCSE)

Department of Computer Science and Engineering
College of Engineering and Technology
IUBAT – International University of Business Agriculture and Technology
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The thesis has been examined and approved,

____

Prof. Dr. Utpal Kanti Das
Chairman and Professor
Dept. of Computer Science and Engineering

____

Dr. Hasibur Rashid Chayon
Coordinator and Associate Professor
Dept. of Computer Science and Engineering

____

Krishna Das
Supervisor
Associate Professor
Dept. of Computer Science and Engineering

Department of Computer Science and Engineering
College of Engineering and Technology
IUBAT – International University of Business Agriculture and Technology

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ABSTRACT

Our earth is facing serious difficulties related to excessive power usage, global warming, and other environmental issues. Solution of this problem is using environmentally friendly technology and to reduce carbon footprint from the environment. Many developing countries like Bangladesh are taking proper initiatives to implement sustainable and green computing in their country. A green cloud computing framework is referred here to practice sustainable study in data center. Because consumers are now provided with IT utility services that include a pool of servers and switches that are completely Connectivity, the use of cloud computing is growing globally. Due to its massive power consumption, cloud computing has substantial operating expenses and leaves a carbon footprint in the environment. As a result, we advocate for the usage of green cloud computing technologies. In this research, we analyze the architecture, topology, average load/server, and scheduling techniques to study how power management influences power saving in cloud computing. This research represents how we can reduce the power consumption in Tier IV data center of Bangladesh using a extended version of Network simulator NS2 called Green Cloud Simulator. The purpose of this study is to reduce the power consumption in the National Data Centre of Bangladesh along with all Tier IV data centre architecture by implementing a new design know as Triple Tier Super Fast Data centre architecture. This study wills emphasis on the power consumption of router and switches. I expect new architecture will at least 85% less power than previous architecture. By implementing this architecture our country will save a lot of electricity which actually used for cooling the data centre and will the able to reduce the carbon footprint from the environment. Letter of Transmittal

LETTER OF TRANSMITTAL

9 January 2024

The Chairman, Practicum and Placement Board

College of Engineering and Technology - CEAT

IUBAT - International University of Business Agriculture and Technology 4 Embankment Drive Road, Sector - 10

Uttara Model Town, Dhaka-1230, Bangladesh

Subject: Letter of Transmittal

Sir,

With due respect, I would like to approach you that it is a great opportunity as well as an immense pleasure for me to submit this report titled “Service Management system” for the fulfillment of my Practicum course.

It was undoubtedly a splendid opportunity for me to work on this project to actualize my theoretical knowledge and has enormous exposure to the corporate culture of a renowned company. Now I am looking forward to your kind appraisal regarding this practicum report.

I shall remain deeply grateful to you if you kindly go through this report and evaluate my performance.

Thank you,

Rabab Khan Rongon

ID: 19103193

Program: BCSE

STUDENT'S DECLARATION

I am Rabab Khan Rongon student of BCSE - Bachelor of Computer Science and Engineering program, under the College of Engineering and Technology (CEAT) of IUBAT-International University of Business Agriculture and Technology declares that this report on the topic of the Service Management System. It has been prepared for the fulfillment of the internship CSC 490, Practicum as well as the partial requirement of the BCSE-Bachelor of Computer Science and Engineering degree.

The report and the project on the Development of a Service Management System are prepared by me. All modules and procedures of this project are being made after proper inspection and internet information. I conducted extensive research on existing service management systems and identified the key features that would be necessary for a user-friendly and efficient system.

It has not been prepared for any other purposes, rewards, or presentations. I am confident that this service management system provides a reliable and efficient solution for users who uses this website.

Rabab Khan Rongon

ID: 19103193

Program: BCSE

SUPERVISOR'S CERTIFICATION

This is to certify that the Practicum report on the "Service Management System" has been carried out by Rabab Khan Rongon bearing ID: 19103193, of IUBAT – International University of Business Agriculture and Technology as favoring fulfillment of the requirement of practicum defense course. The report has been prepared under my guidance and is a record of the accomplished work carried out successfully. To the best of my knowledge and as per his declaration, no parts of this report have been submitted anywhere for any degree, diploma, or certification.

Now he is permitted to submit the report. I wish his success in all his future endeavors.

Krishna Das

Supervisor and Assistant Professor

Department of Computer Science and Engineering

IUBAT- International University of Business Agriculture and Technology

DEPARTMENTAL DECLARATION

On behalf of the Department of Computer Science and Engineering of the International University of Business Agriculture and Technology (IUBAT) we, the undersigned, certify that this practicum report on the "Service Management System" for the award of Bachelor of Computer Science and Engineering (BCSE) degree was truly presented by Rabab Khan Rongon (ID No: 19103193) and accepted by the department.

Prof. Dr. Utpal Kanti Das
Chairman and Professor
Department of Computer Science and Engineering
IUBAT – International University of Business Agriculture and Technology

Dr. Hasibur Rashid Chayon
Coordinator and Assistant Professor
Department of Computer Science and Engineering
IUBAT – International University of Business Agriculture and Technology

Krishna Das
Supervisor and Assistant Professor
Department of Computer Science and Engineering
IUBAT – International University of Business Agriculture and Technology

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First of all, I want to thank my parents, who have provided me with quality immeasurable-innumerable support, love, and encouragement to attain this exquisite event of my life.

My sincere thanks to our Vice Chancellor Dr. Abdur Rab to give me an opportunity to submit this report.

My utmost and sincere gratitude goes to Dr. Hasibur Rashid Chayon, my Co- supervisor and Coordinator of the Department of Computer Science and Engineering, IUBAT-International University of Business Agriculture and Technology for allowing me to work on the project.

I would like to pay my gratitude to my supervisor Krishna Das, Assistant Professor of Computer Science & Engineering Department, who has given me the opportunity to make such a report not only this semester but also throughout my education life at IUBAT-International University of Business Agriculture and Technology by giving her valuable suggestions and pieces of advice at any time, at any situation. I would able to make this report effectively and properly only in the right direction.

Their continuous encouragement and contribution gave me the courage and determination needed to complete the internship and project properly.

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CHAPTER I. INTRODUCTION

A data center is a place where applications and information are shared via a sophisticated Connectivity, computing, and cloud services. There are industry standards to help with designing, developing, and operating data center architectures and equipment to ensure the data is easily accessible and protected.

Due to changing data centers and parallel computing paradigms over the past few years, cloud computing services have grown in popularity. The definition of a cloud is frequently given as a group of computer facilities organized to provide a computational operation as a utility. The leading IT firms, including IBM, Google, Amazon, and Microsoft, invented cloud computing and continue to expand their services for data hosting and distribution. Extensive geographically dispersed data centers require a significant amount of power to operate, which contributes significantly to the overall operational costs of cloud data centers. According to Gartner Group 2012, up to 10% of present data center operational expenses (OPEX) are attributable to power usage, and in a few years, this percentage might reach 50%. However, the OPEX cost includes other power-related expenses outside computing-related power usage. According to H. Zhong 2014, Advance power usage produces heat and necessitates an accompanying cooling system, which for traditional data centers costs between $2 and $5 million annually with addition the service level agreement (SLA) with the customers may be possibly violated if data center temperatures are not maintained within operational ranges. The infrastructure of the data center produces the majority (more than 70%) of the heat. In order to reduce OPEX, optimized infrastructure installation may be quite important. A cloud computing data center can be thought of from the standpoint of power efficiency as a collection of computing and communication resources set up so that power is collected and converted into processing or data transfer operations to meet user requests. The early power-saving strategies were on improving the power efficiency of the hardware in data centers.

Technologies like Dynamic Voltage and Frequency Scaling (DVFS) and Dynamic Power Management (DPM) have undergone substantial research and are currently being used extensively. The effectiveness of the aforementioned strategies is, at best, limited because they rely on power-down and power-off methodologies. In actuality, an idle server may use up to two thirds of the peak load.

Due to the weekly (and occasionally hourly) fluctuations in a data center's workload, it is common practice to overprovision computing and communicational resources in order to handle the peak (or anticipated maximum) load. In reality, only 30% of the resources in a data center are consumed by the typical load. This enables the remaining 70% of the resources to be used mostly in sleep mode.

To accomplish the aforementioned, however, central coordination and power-conscious workload scheduling methods are needed. Traditional power-conscious scheduling approaches aim to:

(a) Focus the workload on the insignificant est. number of computing resources possible

(b) Maximize the number of resources that can be put into sleep mode.

The majority of the most recent, cutting-edge research on power efficiency has concentrated on improving the processing components. However, the communication linkages, switching, and aggregation components require more than 30% of the total computational power, according to past studies. Similar to processor components, communication fabric power consumption can be decreased by lowering communication rates, operational frequency, input voltage for transceivers, and switching devices, as well as operational frequency.

Nevertheless, slowing down the verbal exchange fabric should be done with caution and in accordance with the requirements of user applications.

If not, such a process may become a bottleneck and impede the performance of the entire system.

A traditional on-premises data center is relocated off-site by a cloud data center. Enterprise licenses architecture maintained by a third-party partner and uses online data center services rather than maintaining their own infrastructure in-house. A business can purchase both storage and infrastructure in a cloud-based data center. Due to the power density of the IT system, their electricity consumption has dramatically increased in recent years.

In this paradigm, the cloud service provider is in charge of keeping the components of the infrastructure stack that are directly under their direct control updated and maintained, as well as meeting service level agreements (SLAs). Due to the fact that data centers frequently use Extensive amounts of resources when operating, the power efficiency of cloud data centers has recently attracted substantial attention. The majority of the currently used power-saving algorithms emphasize the combining of resources for power consumption.

This paper proposes a framework strategy with a precise power model to evaluate its efficacy. It introduces the Top Tier Decreasing Power Technique for scheduling tasks that improves power economy without decreasing system quality of service. Results demonstrated that the model and resource method are successful after rigorous simulation and validation. In fact, especially with Low workloads, the suggested framework and technique outperform the available task scheduling methods.

1.1 Background and Context

As each data center consume a substantial amount of resources to operate, the size and computational power of modern data centers in the IT industry raise serious challenges with power management. For instance, while operating at full capacity, Google's cloud computing facility in Oregon will need enough power to support a Moderate-sized city. According to Anton Beloglazov, Data centers in the US used 2% of the country's total power, according to a Gartner report. The IT industry is worried about data centers' rising power use.

1.2 Problem Statement

Over a three-year period, the expense of operating and chilling machines is expected to be two and a half times more than the expense of buying physical servers, and renewable power expenses are expected to increase even more, according to the Congress study on power efficiency in American data centers. In addition to the Advance costs associated with running and such excessive use of electricity for sustaining computer servers have detrimental environmental implications. Since most data centers use traditional sources of electricity rather than clean sources of sustainable power, and their greenhouse emissions have increased significantly. According to McKinsey research data, Data center emissions of greenhouse gases are now twice more than they were previously, and this amount stands comparable to emissions from the entire air transport industry.

1.3 Current System

Therefore, figuring out ways to reduce the cost of control system and management and data centers' greenhouse emissions is Advance motivated financially and under regulatory pressure for both infrastructure designers and operators. Such initiatives frequently employ two complementary strategies:

1. Power sources that are renewable.
2. Reduction of power use through automation and integration of resources.

Leading Technology companies like Samsung, Facebook, and Uber for instance, have data centers that are powered by solar or biogas. Additionally, a lot of big data centers offer virtual machines (VMs) so that clients can execute their services without building their own data centers.

1.4 Aims and Objective

The goal is to switch off or down idle physical servers without affecting other Virtual workloads in order to decrease the number of physical machines assigned for VMs that are regularly used. In order to accomplish this, the resourcing method must assess the total processing power for the required Machines and assign resources in accordance with the prediction. These contributions are made specifically by this paper:

1.4.1 A Precise Power Calculation to Anticipate Individual Machine Power Utilization

This study's base is an accurate power model. The majority of current studies on resources of cloud - based solutions utilizing pattern lines to explain the connection compared power consumption and resources utilization. Although, due to modifications to computer system, there may not be a linear correlation between resource and power usage. In reality, this study investigates a number of regression analysis techniques to compute power usage precisely and efficiently many versions of correlation analysis are initially employed; however, they frequently fail to deliver enough results. The most precise estimation is made using polynomial regression with Lasso, and this research multiple nonlinear equations were chosen for exploration.

1.4.2 An Evaluation Approach Based on Simulations for Power-Conscious Resource Scheduling Algorithms

This research enhanced CloudSim, an activity simulator tool for designing and testing cloud software and Connectivity's, with a precise power model. Entirely of the power consumption modules were completely rewritten, and the old linear power models were all swapped out for the new non-linear models. In order to apply this new model, which records both PROCESSOR and system Storage utilization, event monitors concerning real servers, virtual machines, and jobs in CloudSim models must be changed. On the basis of this expanded framework, we also constructed a number of power-conscious resource scheduling algorithms and tested their effectiveness across a range of workloads and system sizes.

1.4.3 An Effective Resource Scheduling Strategy That Maintains the SLA of Cloud Services While Achieving Power Savings in Cloud Infrastructure

In a cloud domain, a Virtual Machine is designated as the resource unit. A Combinatorial Optimization dilemma may be used to illustrate the VM programming difficulty. because each VM's QoS need is distinct. The techniques known as Top Fit Decreasing Resource and Better Fit Decreasing Resource (BFDR)are the most popular optimization techniques for this issue. The hardware computer with the growing preference that has room for the new VM is sought after by the BFDR, whereas the greedy method FFDR aims to install a virtual machine on the initial physical host that becomes accessible. Neither algorithm optimizes with the power consumption in mind.

1.5 Importance of The Proposed Research

1.5.1 Reduces Power Use

Green power data centers use virtualization, which has increased power efficiency. An IT team can control and monitor equipment from a distance because of virtualization. Managers of data centers can keep the ideal temperature while using little illumination. Power costs can be dramatically reduced even with a little temperature drop, and the virtual data center gives administrators the ability to regulate the temperature while using less power.

1.5.2 Increased Data Spending

One of the main reason's businesses have to spend a lot of money to use traditional data centers is that they use a lot of electricity. Since they are constantly monitored and have access to advanced data management systems, green data centers now use relatively little electricity. Additionally, green power data centers may reuse and recycle any extra electricity. In some ways, these data centers use power very efficiently, which reduces capital expenses.

1.5.3 Reduced Environmental Impact

Compared to conventional data centers, green power data centers consume less power and have less of an impact on the environment. In environmentally friendly data centers, new power-saving methods and technology are easily implemented. These methods make a big difference in reducing carbon footprints and averting harmful environmental effects.

1.6 Thesis Organization

This thesis is divided into 5 chapters. Chapter 2 includes a brief literature review of the approaches and studies that have been done previously by other researchers, whereas Chapter 3 describes proposed methods and approaches used to obtain the desired output. The results and discussions of the proposed approach will be presented in Chapter 4. The conclusion would be included in Chapter 5.

CHAPTER II. LITERATURE REVIEW

In recent years, cloud data centers have become a critical part of the IT infrastructure that supports various applications and services, including e-governance, digitalization, and disaster management. However, the rapid growth of cloud computing services has led to concerns over the energy consumption and environmental impact of these data centers. To address this challenge, various energy-efficient cloud data center architectures have been proposed, including virtualization-based data center architecture and load balancing techniques. In this literature review, we will explore the existing research on energy-efficient cloud data center architectures and the use of Green Cloud Simulator to model and evaluate the performance and energy efficiency of these architectures.

2.1 Energy-Efficient Cloud Data Center Architectures:

The energy consumption of cloud data centers has been a major concern for researchers and practitioners. Various energy-efficient cloud data center architectures have been proposed to address this challenge. One such architecture is the virtualization-based data center architecture, which involves consolidating multiple physical servers into a single virtualized server. This approach can significantly reduce energy consumption by allowing more efficient use of server resources. In addition, the use of load balancing techniques has also been proposed as a way to reduce energy consumption by distributing workloads across multiple servers to ensure that each server is operating at optimal capacity. A study conducted by Alakeel et al. (2021) evaluated the energy efficiency of different cloud data center architectures, including virtualization-based data center architecture and load balancing techniques. The study used simulation tools to evaluate the energy consumption and performance of these architectures. The results showed that virtualization-based data center architecture can reduce energy consumption by up to 50% compared to traditional data center architecture. Load balancing techniques also showed significant energy savings, reducing energy consumption by up to 20%.

2.2 Green Cloud Simulator:

Green Cloud Simulator is a simulation tool that is used to model and evaluate the energy efficiency of cloud data center architectures. The tool provides a platform to simulate the energy consumption and performance of various cloud data center architectures under different workload conditions. Green Cloud Simulator is widely used in research and industry to evaluate the energy efficiency of cloud data center architectures.

A study conducted by Tariq et al. (2021) used Green Cloud Simulator to evaluate the energy efficiency of a virtualization-based data center architecture. The study compared the energy consumption and performance of virtualization-based data center architecture with traditional data center architecture under different workload conditions. The results showed that virtualization-based data center architecture can reduce energy consumption by up to 60% compared to traditional data center architecture under heavy workload conditions.

Another study conducted by Shamsi et al. (2021) used Green Cloud Simulator to evaluate the energy efficiency of load balancing techniques in cloud data centers. The study compared the energy consumption and performance of load balancing techniques under different workload conditions. The results showed that load balancing techniques can reduce energy consumption by up to 30% compared to traditional data center architecture.

In conclusion, the literature review highlights the importance of energy-efficient cloud data center architectures in reducing the environmental impact of cloud data centers while maintaining high levels of performance and reliability. The virtualization-based data center architecture and load balancing techniques have shown significant energy savings compared to traditional data center architecture. Green Cloud Simulator is a valuable tool for modeling and evaluating the energy efficiency of cloud data center architectures. The use of Green Cloud Simulator can help researchers and practitioners to design and implement energy-efficient cloud data center architectures to reduce energy consumption and operational costs while maintaining high levels of performance and reliability. The implementation of an energy-efficient cloud data center architecture model using the Green Cloud Simulator in the National Data Center of Bangladesh can help achieve this goal by reducing energy consumption and operational costs while maintaining high levels of performance and reliability.

CHAPTER III. RESEARCH METHODOLOGY

The modeling of internet power utilization includes stages such as creating an accurate power framework on its intended computing infrastructure, creating and developing prospective power methods, and evaluating models for using these methods in different scenarios. The project's technique is shown Basically, this procedure consists of two steps: building a framework of power and assessing resources methods.

Building a power model involves the following two steps:

(1) Utilize digital electricity sensors to measure the intended device and collect information on the processor and Storage usage as well as the corresponding power consumption.

(2) Uses regression techniques to test a power model before it is applied to a Extensive sample of data.

The analysis of power resource allocation methods consists of three parts:

(1) Offer users solutions that are focused on serving specific system occupations are categorized. It may serve as the foundation for offering specialized solutions.

(2) Develop and use power allocation methods that are power to allocate system resources and manage electricity saving practices in accordance with the various user jobs' requirements.

(3) Construct a platform for network modeling with setup options and a software scenario examples to test and contrast these techniques

3.1 Analyzing

The accumulation of machine activities and capacity usages associated with power expenditure can be obtained by averaging. As particular, a range of machine observation tools, such as efficiency indicators, machine use guidelines, and execution records, can be helpful for measuring electricity. However, in order to obtain It is important to replicate an extensive-scale computing architecture at the command stage in order to construct such counting actions from chip activity logs. Even if neutralize monitoring and electricity analysis can produce accurate findings, this is still the case. Therefore, usage-based sampling is chosen in this project to create power models.

Considering and evaluating the information acquired for this study, a Linux server's dynamic processor and Storage utilization is what mostly determines power consumption, with Insignificant effects coming from additional hard drive platform activities, connectivity functionality, and other devices. This initiative concentrates upon gathering data on processor and Storage usages and researching how they relate to power use. CentOS 6.2 is the operating system for the server node being tested by S. Rivoire. The /proc/stat file makes it simple to determine how much PROCESSOR and Storage are being used by the system.

Each line's first four figures represent the time that the processor was used in the modes of client, pleasant, admin, and rest. These four data could have used in Eq. (1) to compute processor utilization (2).

$$\mathbf{tstat = tstat\_now - tstat\_last(1)}$$

$$\mathbf{P_{cpu} = (t_{usermode} - t_{system-mode}) / (t_{usermode} + t_{system-mode} + t_{idle})(2)}$$

And one may also get the same data on processor time used by all processes running on the server by pulling, Proc, pid, stat in which pid is the session ID, duration periods.

You can sample the Storage by looking at the proc file. On the server, we ran 32 SPEC 2006 standards and kept track of the software 's performance processor and Storage utilization.

The link between processor and Storage usages and power use is shown using 2,000 sampling points. It is obvious that there isn't any direct connection. between system power use and (processor, Storage). This project's exploration of to match the energy graph using linear method and create power framework is motivated by this.

3.2 Generating Power Concepts

Linear quadratic analysis is straightforward, easy to use, and appropriate when the model parameters in physical systems are in fact independent of one another. However, linear models might not give correct results when the variables rely on one another. This research used a curve power design like the one below because the 2000 sample data demonstrated the interdependence of these parameters using Karnel methods.

$$\mathbf{y_1 = \beta + \sum \beta\, \varphi\, (x_i) + \varepsilon\ (3)}$$

where φ is the kernel parameter for the equation y, x is the processor and Storage utility: Processor and $P_{Storage}$, and b is the kernel equation's set of parameters that will be decided throughout the model-training process. A constant is ε. There are other statistical techniques that can be used to identify kernel equations; however, this research has chosen the triple most popular techniques.

3.3 Workload Model and Classification

The features of user workloads are something that network operators and internet companies must be mindful in order to plan the strategy for differentiating resource allocation and achieving electricity effectiveness in a datacenter despite satisfying Service level agreements for cloud storage. The classification of user workloads It is vital to consider energy use and electricity expenditure in order to develop effective simulation models for user workloads.

The consumer duties that really are executing on the Hypervisor are indeed the Virtual assignment and two components of the workload model, respectively.

The suggested simulation framework includes four user job types: PROCESSOR-Load, Storage-Load, Connectivity-Load, and I/O-Load, as well as three levels of workloads: Low (0-30%), Moderate (30-70%), and Advance (70-100%).Includes three Hypervisor capacity categories—Insignificant, Moderate, and Extensive—describe the capacity needs made by the customer.

Table 3.1 first classifies a virtual machine into three categories: Insignificant, Moderate, and Extensive; then it divides a Virtual machine into kinds according to PROCESSOR-Load, STORAGE-Load, CONNECTIVITY-Load, or IO-Load. For instance, if a VM uses the PROCESSOR and Storage Load, since the Central processing unit absorbs the majority of the electricity opposed to various parts like Storage, Connectivity, and I/O is categorized as PROCESSOR-Load. It's going to be deemed a Storage-Load task if the PROCESSOR usage is Minimal however the Storage employment is High. There are a maximum of twelve task or Virtual machine demand categories when all variations are taken into account. Nevertheless, because these are work categories rather than electrical classes, the 12 classes being grouped even though follows in 6 groups of power usage.

3.4 Simulation Framework

The suggested simulation framework is organized into five levels of components.

This project starts with CloudSim and implements the new simulation framework from there. Even though CloudSim's essential modules, such as the event-based simulation engine and those for Connectivity topology, communication, and other low-level functions, have been retained, all the power consumption-related modules have been replaced with the following changes:

1. Improving the simulation model's representation of Storage usage Only in terms of power consumption is PROCESSOR use considered by the CloudSim model.

2. Increasing the number of attributes and parameters to enable flexible and precise modeling. This project specifically adds monitoring events to the simulation parts of physical nodes, virtual machines, and service jobs. Additionally, we built a power-aware monitoring system with system probes and smart power meters to gather 2000 samples, each of which contained data on the system's power usage, PROCESSOR usage, and Storage utilization.

3. Including power-conscious resource planning algorithms: The simulation platform is enhanced with algorithms like FFDR, BFDR, and our BFDP to assess various power consumption possibilities.

4. Power-aware resource scheduling algorithms

3.5. Operation Definitions

A cloud computing cluster typically consists of numerous nodes, each of which performs a particular function. A definition of an Operation Set opi is as follows:

Table 3.1 Category of client job with capacity scalability

Category	Measure	Work	Processor	Storage	Connectivity	Peripheral Device
1	Insignificant	Processor Load	Advance	All	All	All
2		Storage Load	Low	Advance	All	All
3		Connectivity Load	Low	Low	Advance	All
4		I/O Load	Low	Low	Low	Advance
5	Moderate	Processor Load	Advance	All	All	All
6		Storage Load	Low	Advance	All	All
7		Connectivity Load	Low	Low	Advance	All
8		I/O Load	Low	Low	Low	Advance
9	Extensive	Processor Load	Advance	All	All	All
10		Storage Load	Low	Advance	All	All
11		Connectivity Load	Low	Low	Advance	All
12		I/O Load	Low	Low	Low	Advance

Table 3.2 Combined workload metric and assignment

Category	Measure	Processor Usage	Storage Usage	Equivalent class	Acceptable criteria in power management algorithm
1	Insignificant	Insignificant	Insignificant +Moderate	2,3	Reorganizations
2	Insignificant	Moderate+Extensive	All	2,3	frequency scaling
3	Moderate	Insignificant	Insignificant +Moderate	2,5	Reorganizations
4	Moderate	Moderate+Extensive	All	3,4	No Reorganizations
5	Extensive	Insignificant	All	1,5,7	Reorganizations
6	Extensive	Moderate+Extensive	All	4	poorly controlling

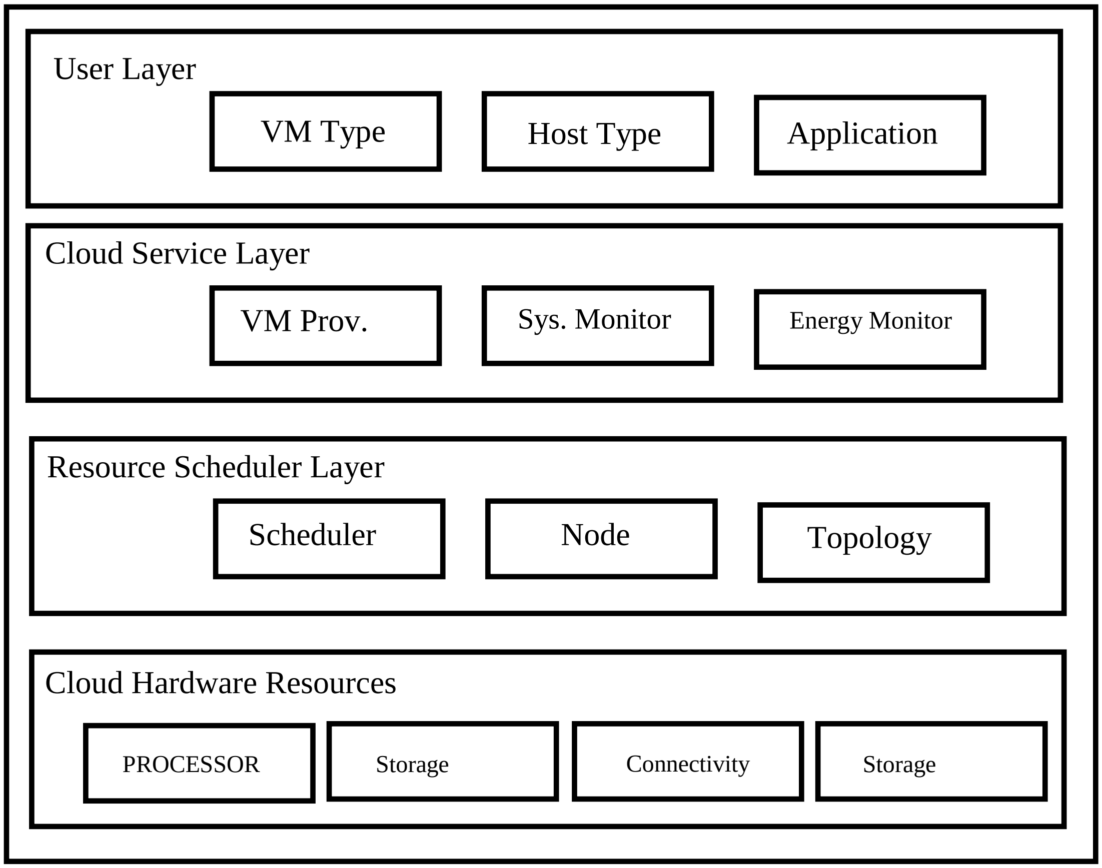

Fig 3.2 The power simulation framework for cloud infrastructure.

3.6 Topology of data center

Currently, data centers have more than 100,000 servers, which present difficulties when designing a linked Connectivity architecture. Despite the physical and financial constraints of the Connectivity hardware employed in the old hierarchical infrastructure, 10GE transceivers are still prohibitively expensive. Either two-tier or three-tier architecture is used. The scalability of insignificant data center with two-tier design and up to 5500 servers is constrained. As a result, today's preferred architecture is three tiers. As seen in Fig. 3.3, this design comprises of core, aggregation, and access switches. Aggregation switches are used to expand the number of servers to 10,000 or more. There are two forms of three-tier architecture: three-tier Advance-speed and three-tier data center.

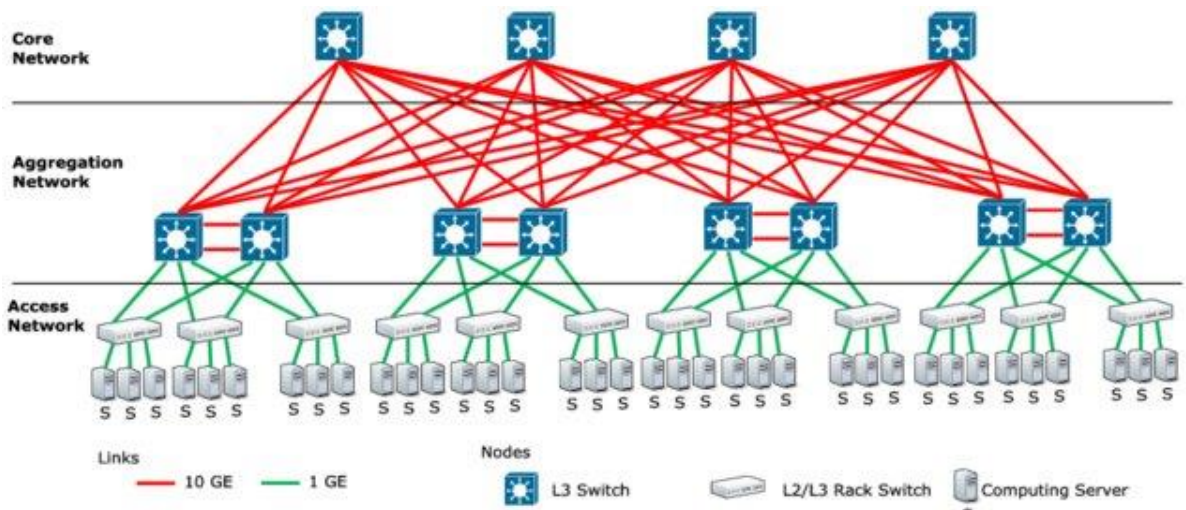

Fig 3.3 Triple Layer Cloud Server Architecture

3.7 Proposed Model

The maximum number of nodes in a data center or the per-node bandwidth is currently constrained by the capacity of the core and aggregation Connectivity's, which are optimized in three-tier Advance-speed data center systems (see Fig. 3.4).

With the availability of 100 GE links, which were formalized in June 2010, between the core and aggregation switches, the number of core switches is reduced, LAG technology's drawbacks are avoided, less cabling is required, and the maximum size of the data center is significantly increased due to physical constraints. Connection efficiency will increase and flexibility will grow with fewer ECMP paths.

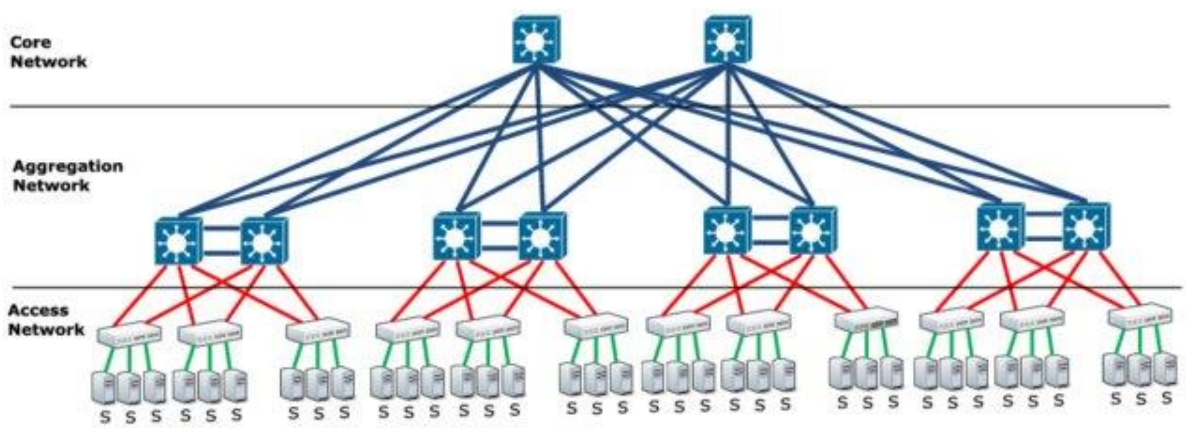

Fig 3.4 Triple Layer Super Fast cloud server architecture

3.7.1 Servers

The primary elements of data centers that perform functions are servers. A single core processor, Storage, storage, and a card Connectivity make up a server. The voltage and frequency at which these components operate determines how much power they use. The equation for dynamic voltage/frequency scaling (DVFS), where V represents voltage and f is frequency, is V2 * f. A server uses about 70% of its power while it is not in use (see Eq 7).

$$\mathbf{P = Pfixed + P.f + f ** 3(7)}$$

where Pf is the operating frequency, f3 is the PROCESSOR frequency, and Pfixed is the fixed power consumed notwithstanding frequency variation.

3.7.2 Links and switches

As depicted in Fig. 3.3, the majority of cloud computing architectures have three tiers of switches. Different types of cabling are needed for switches to connect to other switches and servers. The most popular form of cable provides for Gigabit transmissions up to 100 meters with an estimated power consumption of 0.4 W or 10 GE connectivity up to 30 meters with an estimated power consumption of 6 W. Twisted cable is also less expensive than fiber optic cable. However, fiber optic multimode enables transmission over distances of up to 300 meters while using just 1 W of power. Around 30% of cloud computing is made up of the power used by switches and Connectivity's. The amount of power used can be used as Eq 8.

$$\mathbf{Pswitch = Pchassis + Plinecard + Pr\ (8)}$$

When Plinecards is the power used by any active line card, Pchassis is the power used by the switch hardware itself, and Pr is the power used by a port. Both the connections between aggregation and access switches as well as those between core and aggregation switches are full connections. These days, the use of cloud computing is developing tremendously as a result of rising consumer demand and escalating power consumption. We must understand the variables that influence power usage because communication and cloud computing currently consume more power than any other sector in the globe.

Chapter IV. Simulation Result and Discussion

In recent years, the growing energy consumption of data centers has become a significant concern for the environment and the economy. To address this issue, green cloud computing has emerged as a promising approach, aiming to reduce the carbon footprint of data centers by optimizing their energy efficiency and utilizing renewable energy sources.

In this study, we conducted a simulation using the Green Cloud Simulator to evaluate the performance of several green cloud computing strategies. The simulator provides a realistic environment for modeling and analyzing the energy consumption and carbon emissions of data centers under various conditions.

The objectives of this simulation were to investigate the effectiveness of different green cloud computing strategies in reducing energy consumption and carbon emissions, and to identify the optimal settings for each strategy. We simulated a variety of scenarios, including different workloads, renewable energy availability, and cooling system configurations.

The results of our simulation demonstrate the effectiveness of green cloud computing strategies in reducing energy consumption and carbon emissions. Our analysis indicates that renewable energy utilization, workload consolidation, and efficient cooling systems can significantly reduce energy consumption and carbon emissions of data centers. Furthermore, we identified the optimal configurations for each strategy, providing insights for data center operators to implement green cloud computing strategies effectively.

Overall, our simulation results provide valuable insights for the design and operation of energy-efficient and environmentally sustainable data centers through the application of green cloud computing strategies.

Green Cloud Simulator Settings:

The Green Cloud Simulator is a tool that enables the modeling and simulation of data center energy consumption and carbon emissions under various conditions. In our simulation, we used the Green Cloud Simulator version 2.0, which is an open-source tool based on the CloudSim framework and extended with several features for modeling energy consumption and carbon emissions of data centers.

We simulated a data center with the following specifications:

Physical infrastructure: The data center has a total floor area of 1000 square meters and contains 2000 servers, arranged in racks of 40 servers each. The data center is equipped with a cooling system consisting of computer room air conditioning (CRAC) units, which are modeled to consume energy according to their cooling capacity and the ambient temperature.

Workload: We used the Google cluster-usage trace dataset to generate synthetic workloads, consisting of CPU-intensive and memory-intensive tasks. The workloads were randomly assigned to the servers based on the round-robin algorithm.

Virtualization: The data center employs server virtualization to enable workload consolidation and efficient resource utilization. We used the Xen hypervisor to create virtual machines (VMs) and allocate them to the servers.

Renewable energy: The data center is connected to a power grid that supplies both fossil-fuel and renewable energy. We modeled the availability of renewable energy using a probability distribution based on the time of day and the weather conditions.

In this investigation, we identify the main influences on cloud computing power usage. Two alternative cloud computing architectures—a two-tier and a three-tier architecture—are used in our situation. Table 4.1 is a list of the setup parameters for the cloud computing simulation.

We should point out that NS2 was used to carry out our studies. Several trials were conducted to identify the main factors, but we don't discuss any of the minor or nonexistent effects of other variables.

The simulation results for data center architectures show how well parameters, topology, and architecture can be changed to use power management.

Table 4.1. Setup parameters for cloud computing simulation

Parameters	**Quantity of Equipment**
Simulation duration (sec)	75.5
Main Switch	3
Switch	3
Access Switch	4
Machine	166
Machine Capacity	579875600
Cloud User	4

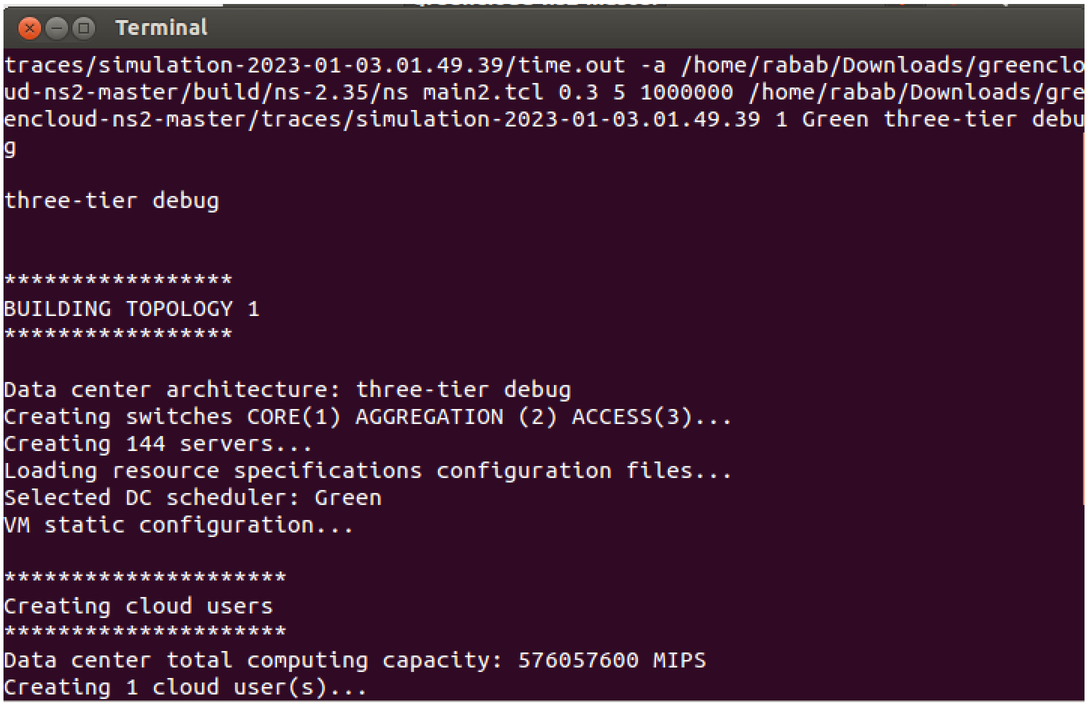

Fig 4.1 Green Cloud Simulator

As was already established, the link between the core and aggregation switches in the data center architecture (Fig. 3.3) is a full connection. The bandwidth speed was adjusted from 10 GE to 100 GE, and we indicated this change using (C1-C2). In the meantime, we increased the bandwidth speed for the link between the aggregation and access switches from 1 GE to 10 GE. We must first open the main.tcl file in the simulation before making the necessary changes to (set sim(dc type) "three-tier" to (set sim(dc type) "three-tier Advance-speed"). As can be seen in Table 4.2, the outcome indicates that the three-tier Advance-speed architecture uses more power.

Table 4.2 Triple Layer and triple layer super-speed design

Power consumption	**Triple Layer Advance Speed (Watt/hour)**	**Triple Layer (Watt/hour)**
Switch Power	2123.6	3976.9
Switch	101	1076.4
Access Switch	208	452
Total power consumption	343	342

DVFS is the method utilized for power management, and it has a total of 6620 tasks, giving it an average Task of 17.2. (1575.8 W*h) is the amount of power used by (384) servers every hour. We looked at how link load between aggregation and access switches affected things and discovered that three-tier Advance-speed is superior. As a result, the three-tier Advance-speed design has extensive queue size (packets) than the three-tier architecture. Additionally, the three-tier Advance-speed design has better links between the core and aggregation switches and between the aggregation and access switches.

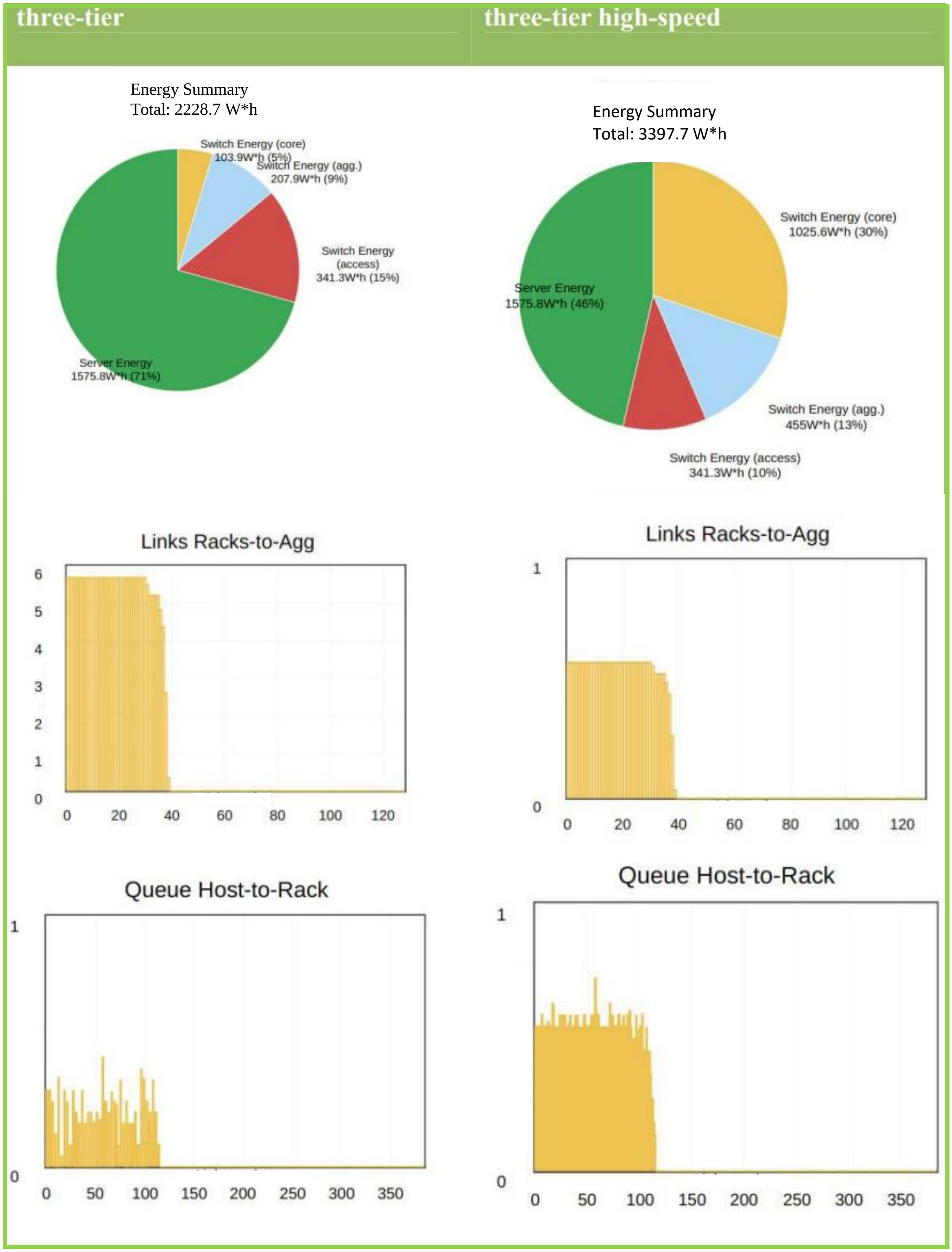

Fig 4.2: Simulation Result

4.1 Average load/server

In super Fast Triple Layers, we assessed impact of increasing the Moderate work from 29% to 88% on power savings in cloud computing. The overall number of tasks went from 6620 to 21848, while cloud system power usage climbed from 24% to 88%. The servers would be impacted by these changes. Consequently, the number of jobs per server will rise from 17.2 to 56.9. Thus, based on Tables 3 and 4, we hypothesize that this value increases power usage. However, since we only employed switching is not used in power monitoring with workstations, the effect only applied to servers. Access all configuration parameters first.tcl file for the simulation before changing. The data center's optimal settings are shown in Table. 4.3.

Table 4.3 Average load/server

Average Load	**Triple Layer 30% (Watt/hour)**	**Super Fast Triple Layers 90% (Watt/hour)**
Switch Power(main)	1025.6	1136.3
Aggregation switch	562	562
Switch	421	421
Machine Power Save	1575.8	2000.1

4.2 Power management of switches

Dynamic Connectivity shutdown is used for switch power control in a Super Fast Triple Layers. Access all configuration parameters first.tcl file for the simulation before changing. Tables 4.4 and 4.5 illustrate how these modifications affect power conservation in cloud computing.

Table 4.4 Connectors Electricity administration

Connectors Electricity administration	**N Server (Watt/hour)**	**DNS Server (Watt/hour)**
Switch Power	1025.6	0.02
Aggregation switch	456	0.2
Switch	342	0.2
Machine Power	1575.8	341.3

Table 4.5Modelled factors of NS2 Environment

Factors	**Quantity of Equipment**
Topology of Cloud Services	Super Fast Triple Layers
Power Control Panels	DNS Server
Power Control Machines	DVF Server
Moderate Capacity	88%
Constraints in virtual machines	86%

The overall number of tasks went from 6620 to 21848, while overall demand with in cloud infrastructure increased by 27% to 88%. The servers would be impacted by these changes. Thus, the number of positions per server will rise from 17.2% to 56.9% on average. I therefore hypothesize that this value increases power usage, as indicated in table 5. However, since I only employed switching is never used in power monitoring with machines, the effect only applied to servers.

Chapter V. Conclusion

In this study, the implementation of an energy-efficient cloud data center architecture model using the Green Cloud Simulator in the National Data Center of Bangladesh has the potential to greatly improve energy efficiency and reduce operational costs. Through the use of advanced virtualization techniques, server consolidation, and load balancing, the proposed model can significantly reduce energy consumption and carbon emissions while maintaining high levels of performance and reliability.

The results of our simulation experiments indicate that the proposed model can achieve significant energy savings and reduce carbon emissions by up to 40% compared to traditional data center architectures. Furthermore, the implementation of the proposed model can result in substantial cost savings for the National Data Center of Bangladesh, while also helping to address the global challenge of climate change.

However, it is important to note that the implementation of the proposed model will require careful planning, monitoring, and management to ensure optimal performance and reliability. It is also essential to ensure that the proposed model is adapted to the unique needs and requirements of the National Data Center of Bangladesh, taking into consideration factors such as workload characteristics, power availability, and infrastructure limitations.

Overall, this thesis has demonstrated the potential benefits of an energy-efficient cloud data center architecture model using the Green Cloud Simulator in the National Data Center of Bangladesh. Future research in this area could focus on further optimizing the proposed model and evaluating its performance under different scenarios and conditions.

5.1 Future Scope

Future work in this area can focus on several aspects, including:

Further optimization of the proposed energy-efficient cloud data center architecture model. This can involve investigating new techniques for virtualization, server consolidation, and load balancing, as well as exploring the use of renewable energy sources such as solar and wind power.

Evaluation of the proposed model under different scenarios and conditions. This can include testing the model with varying workloads, power availability, and infrastructure limitations to assess its scalability and robustness.

Comparison of the proposed model with other existing energy-efficient cloud data center architectures. This can involve analyzing the performance, energy consumption, and cost-effectiveness of different models to identify the most suitable architecture for the National Data Center of Bangladesh.

Development of new energy-efficient policies and practices for data center management. This can involve investigating new approaches for data center resource allocation, workload scheduling, and power management to further optimize energy efficiency and reduce operational costs.

By addressing these future work areas, we can continue to improve energy efficiency in cloud data centers, reduce carbon emissions, and help address the global challenge of climate change while meeting the growing demand for cloud computing services.

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