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كلية الدراسات العليا

جامعة السودان للعلوم والتكنولوجيا

Performance Enhancement of Power Consumption in Cloud Computing

تحسين أداء إستهلاك الطاقة في الحوسبة السحابية

A Thesis Submitted in Partial Fulfillment of the Requirement for the Degree of M.Sc. In Electronics (Computer and Networks)

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Dedications

Those who guided me through my journey and supported me all through the way,

To my parents,

To my brothers,

To my teachers,

To my colleagues and friends,

To all who have been a great source of motivation and inspiration.

Acknowledgement

I would like first to thank my thesis advisor Dr. Mohammed Elghazali Hamza Khalil for granting me the opportunity to write on this topic, and for his clear instructions and guidance. I am grateful to him for being always there to give me advice whenever I needed them, and especially for his patience with me.

Thanks for all who help me in my study and academic life.

Abstract

The power consumption of physical and virtual machines is a major challenge for small to large scale cloud computing data centers. Tow states of the virtual machine, active state if selected by cloudlet and idle state if not selected. Two typed of works applied which are existing work and proposed work. In existing work non-power aware data center, the power consumption used time-shared data center that discarded cloudlet file size to selected VMs. To performance enhanced of power consumption in existing work applied power-aware data center in proposed work used intelligent distribution of cloudlets that according cloudlet file size organized cloudlet on five range to selected VMs. The result shows in existing work that five VMs selected by five cloudlets, which consumed all power of the host. VM1 difference in existing work to proposed work by selected cloudlet1 with file size 300 to consumed 1000 second in existing work and selected three cloudlets which are cloudlet1 with file size 300, cloudlet2 with file size 400 and cloudlet3 with file size 500 to consumed 2999.99 second in proposed work, so there is positive relationship of VM execution time and number of cloudlet that selected by VM. That positive relationship affected positively to power consumption of VM, but in the same time, the VM2 and VM3 not selected by cloudlet stayed in idle state near to zero power consumption and zero execution time in proposed work to reduced power consumption of host from 7.134 KW to 6.562 kW with difference 0.572 kw. VM4 and VM5 selected by cloudlet4 and cloudlet5 in two work there is no change similar to VM2 and VM3. Performance enhancement of VMs power consumption reduced the cost to increased lifetime and reduced carbon footprints to make environment-friendly.

المستخلص

يمثل استهلاك الطاقة للأجهزة المادية والافتراضية تحديًا كبيرًا لمراكز بيانات الحوسبة السحابية الصغيرة إلى الكبيرة النطاق. للجهاز الافتراضى حالتين، الحالة النشطة عند اختيارة بواسطة السحابة و الحالة الخاملة عند عدم اختيارة. تم التطبيق لنوعين من العمل هما العمل الحالي و العمل المقترح. في العمل الحالى غير المطلع لاستهلاك طاقة مركز البيانات بتطبيق مشاركة الوقت و تجاهل حجم ملف السحابة نتج عنه الأجهزة الافتراضية الخمسة تم تسليمها للخمسة سحب مما أدى الى استهلاك طاقة المضيف بأكملها. لتحسين أداء استهلاك الطاقة فى مركز البيانات في العمل الحالي تم تطبيق الطاقة المطلعة في العمل المقترح باستخدام التوزيع الذكى تبعاً لحجم ملف السحابة بتنظيم السحب الى خمسة فرق لترشيح الماكينة المناسبة. في العمل الحالي أظهرت النتائج ان الخمسة سحب تم ترشيحها للخمسة ماكينات افتراضية و الماكينة الافتراضية1 رشحت للسحابة1 بحجم ملف يساوى 300 استهلكت زمن قدره 1000 ثانية، اما في العمل المقترح الماكينة الافتراضية1 رشحت لها ثلاثة سحب هي سحابه1 بحجم ملف 300 و سحابة2 بحجم ملف 400 و سحابة3 بحجم ملف 500 و استهلكت زمن قدره 2999.99 ثانية، هذا أدى اى وجود علاقة طرديه بين وقت تنفيذ الماكينة الافتراضية و عدد السحب التي رشحت لها، هذه العلاقة الطرديه تؤثر طرديا على استهلاك طاقة الماكينة الافتراضية و في الوقت ذاته الجهاز الافتراضى2 و الجهاز الافتراضى3 لم يتم ترشيحهم لاى من السحب أصبحت في حالة خمول مما نتج عنه استهلاك للطاقة اقرب للصفر وات و زمن مستهلك قدره صفر ثانية في العمل المقترح مما أدى الى تقليل إستهلاك طاقة المضيف من 7.134 وات الى 5.562 وات بفرق قدرة 0.752 وات. الماكينة الافتراضية4 و الماكينة الافتراضية5 تم ترشيحهما للسحابه4 و السحابه5 دون تغيير في العملين الحالي و المقترح. تحسين إستهلاك الطاقة في الماكينة الافتراضية نتج عنه تقليل إهدار المصادر و تقليل إستهلاك الطاقة الذى بدوره يؤدي إلى تقليل التكلفة و تقليل آثار بصمة الكربون على المناخ و جعله صديقاً للبيئة .

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List of Abbreviations

ATF	Three-Threshold Framework
AWS	Amazon Web Service
CRM	Customer Relationship Management
DPM	Dynamic Power Management
DPS	Dynamic Performance Scaling
DVFS	Dynamic Voltage and Frequency Scaling
EC2	Elastic Compute Cloud
ESDs	Energy Storage Devices
GUI	Graphical User Interface
IaaS	Infrastructure-as-a-Service
KMI	Key Management Infrastructures
MIPS	Million Instruction Per Second
NIST	National Institute of Standards and Technology
OC	Operational Cost
OS	Operating System
PaaS	Platform-as-a-Service
PM	Physical Machine
PPVMP	power-aware and performance-guaranteed VMP
QoS	Quality of Service
RR	Round Robin
SaaS	Software-as-a-Service
SLA	Service Level Agreements
SOA	Service-Oriented Architecture
SPM	Static Power Management
TCO	Total Cost of Ownership

TCO	Total Operational Cost
VM	Virtual Machine
VMM	Virtual Machine Migration or Virtual Machine Manager
VMP	Virtual Machine Placement
VPME	VM Placement Maximum Energy Efficiency

Chapter One

Chapter One

Introduction

1.1 Preface

Cloud computing is an emerging technology which plays a vital role in effective implementation of lower-cost computation platform. Cloud computing can provide such an environment for optimum utilization of resources [1]. The rapid growth today in Information and Communication Technology (ICT) demands the increased use of cloud data centers. Reducing computational power consumption in the cloud data center is one of the challenging research issues in the current era.

Correspondingly, power consumption is directly proportional to a number of resources assigned to tasks. So, the power consumption can be reduced by a demotivating number of resources assigned to serve the task [2]. The growth of the demand for computational power by scientific, business and web-applications has led to the creation of large-scale data centers [3]. The expected total volume of carbon emission will be around 1430 million metric tons. The data centers will be responsible for 18% of CO_2 emission by the year 2020 [4]. One solution is to reduce the physical data centers which can reduce energy consumption. This can be possible through virtualization technology which allows the physical machines in data centers to host multiple virtual machines.

Thus saving a sufficient amount of power and enhance the data center efficiency. However, if power consumption continues to increase, power cost can easily overtake hardware cost by a large margin. This situation calls for a major step for carrying out inventions to reduce the energy consumption and cost of computations [5].

1.2. Problem Statement

The growing demands of consumers for computing infrastructure are encouraging the company and institutes to deploy a large number of data centers , all over the world that consumes a very large amount of power. An increasing amount of power consumption by data centers is one of the reasons for the increase in the level of carbon dioxide in our ecosystem. A major challenge for Green Cloud is to automatically make the scheduling decision for dynamically selected virtual machines among physical servers to meet the workload requirements meanwhile saving energy.

1.3. Objectives

1.3.1 Main Objectives

The aim of the green cloud internet data center is to reduce power consumption.

1.3.2. Specific Objectives

- To investigate on the same side it leveraging VM selection algorithms according to cloudlet file size.
- To implement time share for power saving in the proposed algorithm in CloudSim.
- To evaluate the performance of the proposed approach to selected VM according to cloudlet files size.
- To used VM intelligent distribution.

1.4. Proposed Method

Simulated the cloud environment into CloudSim simulation software which is based on Java and coded with Java editors and compilers such as Eclipse or Net beans, in this case, the Eclipse was selected. Then a generation began by creating only one host contains five VM and five cloudlets. The broker binds specific cloudlets to a specific VM. In existing work, the broker discarded cloudlet file size to select VM, and in proposed work, the broker according to cloudlet file size selected VM.

1.5. Scope of Research

This research focused on Infrastructure-as-a-Service (IaaS) enhancement of Power Consumption Performance in Cloud Computing in part of the physical and virtual machine.To reduce the power consumption of the data center applied some conditions and algorithm of cloudlet to selected VMs by the broker. These conditions related to the specification of cloudlet file size and VMs.

1.6. Thesis Outline

The research was organized as follows; Chapter Two present literature review and related works, Chapter Three, explain the methodology, while Chapter Four presents the results and discussion, Chapter Five is the conclusion and recommendation were included.

Chapter Two

Chapter Two

Literature Review

2.1. Introduction

Over the last few years, cloud computing services have become increasingly popular due to the evolving data centers and parallel computing paradigms. The notion of a cloud is typically defined as a pool of computer resources organized to provide a computing function as a utility. The major ICT companies, such as Microsoft, Google, Amazon, and IBM, pioneered the field of cloud computing and keep increasing their offerings in data distribution and computational hosting [5- 6].

Computing resources that are available on demand, elimination of an up-front commitment by cloud users and the ability to pay per use of computing resources are benefits of cloud computing. Consequently, electrical power is consumed increasingly and becomes a major concern with more and more suppliers began offering cloud computing services; these services are convenient to users but consuming a lot of energy. By applying the virtualization technology, in accordance with the requirements of the users to configure a virtual machine, both the computing environment and resource management problems can be solved [3].

2.2. Definition of Cloud Computing

Cloud computing is the sharing of computer hardware and software resources over the internet so that anyone who is connected to the internet can access it as a service in a seamless way [7]. From the energy efficiency perspective, a cloud computing data center can be defined as a pool of computing and communication resources organized in the way to transform the received power into computing or data transfer work to satisfy user demands [6]. Cloud is a parallel and distributed computing system consisting of a collection of inter connected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service level agreement (SLA) established through negotiation between the service provider and consumers [8].

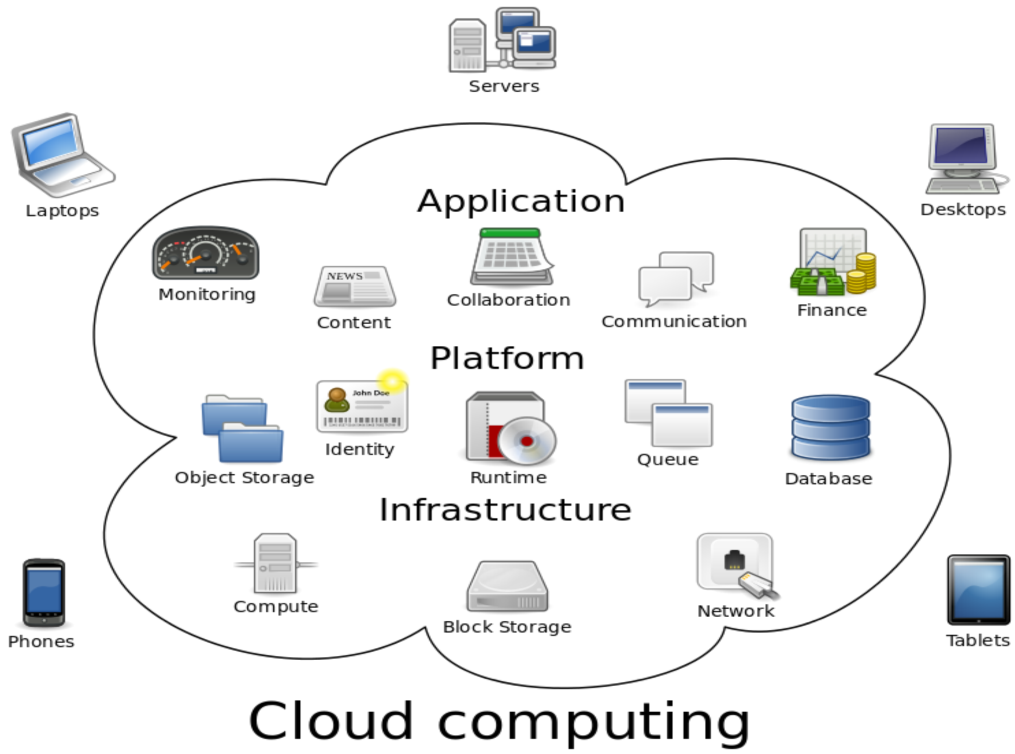

Figure 2-1: Cloud Computing [9]

Definition of Cloud computing by NIST is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction [9, 10].

2.3. Cloud Computing Entities

Cloud providers and consumers are the two main entities in the business market. However, service brokers and resellers are the two more emerging service level entities in the Cloud world, which were explained in the following:

- Cloud Providers: Includes Internet service providers, telecommunications companies, and large business process outsourcers that provide either the media (Internet connections) or infrastructure (hosted data centres) that enable consumers to access cloud services. Service providers may also include systems integrators that build and support data centers hosting private clouds, and they offer different services to the consumers, the service brokers or resellers.
- Cloud Service Brokers: Includes technology consultants, business professional service organizations, registered brokers and agents, and influencers that help guide consumers in the selection of cloud computing solutions. Service brokers concentrate on the negotiation of the relationships between consumers and providers without owning or managing the whole Cloud infrastructure. Moreover, they add extra services on top of a Cloud provider's infrastructure to make up the user's Cloud environment.
- Cloud Resellers: Resellers can become an important factor of the Cloud market when Cloud providers expand their business across continents. Cloud providers may choose local ICT consultancy firms or resellers of their existing products to act as resellers for their Cloud-based products in a particular region.
- Cloud Consumers: End users belong to the category of Cloud consumers. However, also Cloud service brokers and resellers can

belong to this category as soon as they are customers of another Cloud provider, broker or resell [10].

2.4. Cloud Computing History

Cloud is entered into the market from the past. Though it took some time to agree and start using cloud technology, many IT companies have come forward to offer various types of cloud services [11]. The underlying concept of cloud computing was introduced way back in the 1960s by John McCarthy. His opinion was that "computation may someday be organized as a public utility." Similarly the characteristics of cloud computing were explored for the first time in 1966 by Douglas Parkhill in his book, The Challenge of the Computer Utility.

The history of the term cloud is from the telecommunications world, where telecom companies started offering Virtual Private Network (VPN) services with comparable quality of service at a much lower cost. Initially, before VPN, they provided dedicated point-to-point data circuits which were wastage of bandwidth. But by using VPN services, they can switch traffic to balance the utilization of the overall network.

Cloud computing now extends this to cover servers and network infrastructure. Many players in the industry have jumped into cloud computing and implemented it. Amazon has played a key role and launched the Amazon Web Service (AWS) in 2006. Also, Google and IBM have started research projects in cloud computing. Eucalyptus became the first open-source platform for deploying private clouds [12].

2.5. Characteristics of cloud computing

Cloud computing must have some characteristics to meet expected user requirements and to provide qualitative services. According to NIST, these five essential characteristics can be classified as:

- On-demand self-service: A consumer can access different services viz. computing capabilities, storage services, software services etc. as needed automatically without service provider's intervention.
- Broad network access: To avail cloud computing services, the internet works as a backbone of cloud computing. All services are available over the network and are also accessible through standard protocols using web-enabled devices viz. computers, laptops, and mobile phones.
- Resource pooling: The resources that can be assigned to users can be processing, software, storage, virtual machines and network bandwidth. The resources are pooled to serve the users at a single physical location and at the different physical location according to the optimality conditions (e.g. security, performance, consumer demand). The cloud gives an impression of resource location independence at a lower level (e.g. server, core) but not at the higher level (e.g. datacenter, city, country).
- Rapid elasticity: The beauty of cloud computing is its elasticity. The resources appear to users as indefinite and are also accessible in any quantity at any time. The resources can be provisioned without service provider intervention and can be quickly scale in and scale out according to the user needs in a secure way to deliver high quality services.
- Measured service: A metering capability is deployed in a cloud system to charge users. The users can achieve the different quality of services at different charges in order to optimize resources at the different level of abstraction suitable to the services (e.g. SaaS, PaaS and IaaS) [13]-[14].

2.6. Cloud Computing Technologies

There are certain technologies that are working behind the cloud computing platforms making cloud computing flexible, reliable, and usable. These technologies are:

2.6.1. Virtualization

Virtualization is a technique, which allows sharing a single physical instance of an application or resource among multiple organizations or tenants (customers). It does so by assigning a logical name to a physical resource and providing a pointer to that physical resource on demand [11, 15]. Virtualization is a technique that allows the sharing of one physical server among multiple virtual machines (VM), where each VM can serve different applications. Virtualization means "something which isn't real", but gives all the facilities of a real [16]. The advantage of cloud computing is the ability to virtualized and share resources among different applications with the objective for better server utilization [6], Virtualization is the process of converting physical IT resource into a virtual IT resource. Virtualization is the "creation of a virtual (rather than actual) version of something, such as a server, a desktop, a storage device, an operating system or network resources". Virtualization is Creation of a virtual machine over the existing operating system and hardware is known as Hardware Virtualization. A Virtual machine provides an environment that is logically separated from the underlying hardware. Virtualization has three characteristics that make it very related to cloud computing which is [10, 13]:

- Partitioning: By partitioning the available resources, many applications and operating systems can run in a single physical system.

- Isolation: By isolation, each virtual machine can run in its host with other virtual machine without effect on others. So, if one virtual instance failed, it doesn’t affect the other virtual machines.
- Encapsulation: A virtual machine encapsulated and stored as a single file, so a virtual machine can be presented to an application as a complete entity without interfering with another application.

Virtualization types can be categorized into the following:

- Full Virtualization: In full virtualization, the hypervisor or virtual machine manager (VMM) runs on the top of the hardware and controls the guest operating access to the hardware. The advantage is that it’s easy to use and can improve the performance by removing one layer from the hardware. Inside the VM, The guest operating system and applications run on the top of virtual hardware provided by the hypervisor without any modification to the guest operating system.
- Para-Virtualization: In Para virtualization, the guest operating system is modified due to the fact that it can be operated in the virtual environment. Para virtualization provides a thin software interface between the host hardware and the guest operating system which improves the performance, and the guest operating system which is aware of the fact that it is running in a virtualized environment can interact with the hypervisor.
- Partial Virtualization: In partial virtualization, also known as operating system (OS) layer virtualization, a virtualization layer is run on top of the host OS. It allows to virtualized the host OS and thus does not use the hypervisor at all, running multiple instances of the same OS in parallel. OS-layer virtualization is more efficient as compared to other approaches, but the drawback is that

since all the VMs share the same kernel, thus the guest OS must be the same as host OS [17].

2.6.2. Service-Oriented Architecture

Web Services and Service Oriented Architecture (SOA) are not new concepts; however, they represent the base technologies for cloud computing. Cloud services are typically designed as Web services, which follow industry standards, including WSDL, SOAP, and UDDI. A Service Oriented Architecture organizes and manages Web services inside clouds [12]. An SOA also includes a set of cloud services, which are available on various distributed platforms [18].

2.6.3. Grid Computing

A form of distributed and parallel computing whereby a super and virtual information processing system is composed of a cluster of network loosely coupled computers acting in concert to perform very large tasks [8].

2.6.4. Utility Computing

The packaging of computing resources such as computation and storage as a metered service similar to a traditional public utility such as electricity [8].

2.7. Cloud Computing Deployment models

Cloud systems can be deployed in four forms viz. private, public, community and hybrid cloud as per the access allowed to the users and are classified as in Figure 2-2

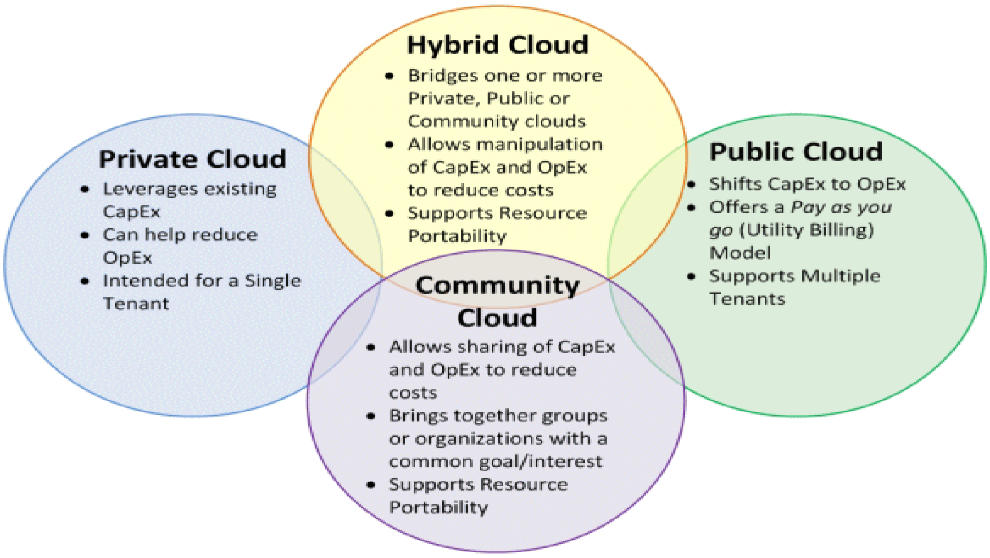

Figure: 2-2 Cloud Computing Deployment models [11]

- Private cloud: This deployment model is implemented solely for an organization and is exclusively used by its employees at the organizational level and is managed and controlled by the organization or third party. The cloud infrastructure in this model is installed on premise or off premise. In this deployment model, management and maintenance are easier, security is very high, and the organization has more control over the infrastructure and accessibility.
- Public cloud: This deployment model is implemented for general users. It is managed and controlled by an organization selling cloud services. The users can be charged for the time duration they use the services. Public clouds are more vulnerable to security threats than other cloud models because all the application and data remains publicly available to all users making it more prone to malicious attacks. The services on the public cloud are provided by proper authentication [19]. Cloud infrastructure available for general public and general usages. The cloud infrastructure is provisioned for open use by the general public. It may be owned,

managed, and operated by a business, academic, or government organization, or some combination of them. It exists on the premises of the cloud provider [20].

- Community cloud: This cloud model is implemented jointly by many organizations with shared concerns viz. security requirements, mission, and policy considerations. This cloud is managed by one or more involved organizations and can be managed by the third party. The infrastructure may exist on premise to one of the involved organization, or it may exist off premise to all organizations [19]. The cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises [21].
- Hybrid cloud: This deployment model is an amalgamation of two or more clouds (private, community, public or hybrid). The participating clouds are bound together by some standard protocols. It enables the involved organization to serve its needs in their private cloud, and if some critical needs (cloud bursting for load-balancing) occur, they can avail public cloud services [19]. It uses a combination of public cloud, private cloud and even local infrastructures, which is typical for most IT vendors [22].

2.8. Cloud Computing Service Models

Cloud computing service can be classified into three major models, as shown in Figure 2-3 it includes [14, 23].

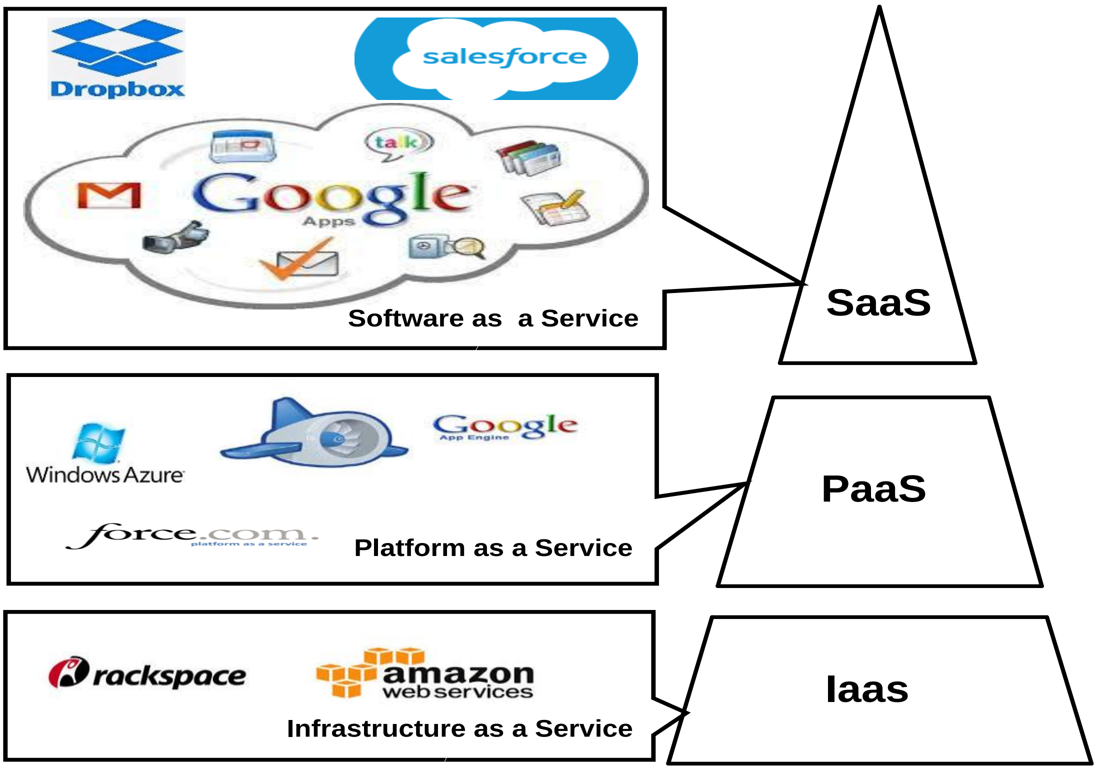

Figure 2-3: Cloud Computing Service [24]

Infrastructure as a Service (IaaS): is a single tenant cloud layer where the Cloud computing vendor's dedicated resources are only shared with contracted clients at a pay-per-use fee. This greatly minimizes the need for the huge initial investment in computing hardware such as servers, networking devices and processing power.

They also allow varying degrees of financial and functional flexibility not found in internal data centers or with co-location services, because computing resources can be added or released much more quickly and cost-effectively than in an internal data center or with a co-location service. However, corporate decision makers must be aware of the capital outlay shift from a periodic fixed expense payment reflected on the income statement to an operational expense increase [10].

Software as a Service (SaaS)**:** is a software delivery model in which applications are accessed by a simple interface such as a web browser over the Internet. The users are not concerned with the underlying cloud infrastructure and even not concern about network, operating systems, servers, platform and storage. This model also eliminates the needs to install and run the application on the local computers.

SaaS term is popularized by Salesforce.com that distributes business software on a subscription basis and not on a traditional on-premise basis. This is the best known solution for Customer Relationship Management (CRM). Now SaaS has now become a common delivery model for most business applications, including accounting, collaboration and management. Applications like social media, office software, and online games which enrich the family of SaaS-based services, for example like web Mail, Google Docs, Microsoft online, NetSuit, MMOG Games, Facebook and many more [13].

The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g., web-based email), or a program interface. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user specific application configuration settings [21].

Platform as a Service (PaaS)**:** is the deployment of operating systems, programming languages, libraries, services, and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure, including network, servers, or operating systems, but has control over the deployed and possibly configuration settings for the application-hosting environment [20]. In this model, the cloud provider delivers a computing platform. It includes the operating system, programming language execution environment, database and web server.

Amazon Elastic Compute Cloud (Amazon EC2) is an example of IaaS Cloud Service Model Cloud computing has enabled IT organizations and individual to gain benefits, such as automated and rapid resource provisioning, flexibility, high availability and faster time to market at a reduced total cost of ownership. Although there are concerns and challenges, the benefits of cloud computing are compelling enough to adopt it.

2.9. Cloud Computing Architecture

Cloud computing system can be divided into two sections: the front end and the back end. They both are connected with each other through a network, usually the internet. The front end is what the client (user) sees whereas the back end is the cloud of the system. The front end has the client's computer, and the application required to access the cloud and the back has the cloud computing services like various computers, servers

And data storage. Monitoring of traffic, administering the system and client demands are administered by a central server.

It follows certain rules, i.e. protocols and uses special software called the middleware. Middleware allows networked computers to communicate with each other [22]. Figure 2-4 shows the different layers of cloud computing architecture.

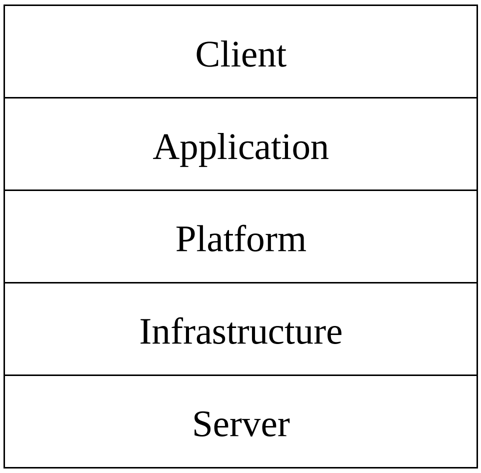

Figure 2-4: layers of cloud computing architecture

A cloud client consists of computer hardware and/or computer software which relies on cloud computing for application delivery, or that is specifically designed for the delivery of cloud services. A cloud application delivers "Software as a Service (SaaS)" over the internet, thus eliminating the need to install and run the application on the user's system.

Important characteristics of this are Network-based access and management of commercially available software that is managed from centralized locations and enabling customers to access these applications remotely through the internet. Examples of the key providers are SalesForce.com (SFDC) NetSuite, Oracle, IBM and Microsoft.

Google Apps is the most widely used SaaS Server consists of the characteristic computer hardware and software required for the delivery of the above-mentioned services. All the above-mentioned services are pay per use, which makes cloud computing an attractive option for those organizations which cannot afford to buy, installing and maintaining the required services [22].

2.10. Cloud Computing Platforms and Providers

Over the past few years, enterprises, small and large businesses are shifting towards the cloud according to the growing demands of enterprises and companies increased the utilization of cloud computing services. The market-leading companies expanded their data centers to support the services they have built. Each company runs their website and services built on top of tons of computing infrastructure. Some of the market leading cloud computing providers are:

- Amazon
- Google
- Microsoft
- Sales force

There are other cloud computing providers who exist in the market and provide services to their customers. The aim of all cloud computing providers is to make it essential for individual software developers and large companies to use the services they offer. As the companies dip into cloud computing with the use of the single app and as their business grows, the need for more apps grows. Several cloud platforms exist from the last few decades which includes open source software like an open stack, other software solution such as VMware, and Amazon web service [25].

2.11. Challenges of Cloud Computing

This emergent cloud technology is facing many technological challenges in different aspects of data & information handling & storage. Some of the important challenges are:

- Availability & reliability
- Security & Privacy
- Interoperability

- Performance
- Portability

The challenges as mentioned are the most important and concerned points that should be processed for the betterment. Cloud is the way to go, as it allows them to set up data-exchange programs that enable multiple deployments to work together. Non-critical tasks such as development and test workloads can be done using public cloud whereas critical tasks that are sensitive such as organization data handling are done using a private cloud.

A community cloud is shared manually among different organizations that belong to the same community or area. Currently, although a few major players lead the market, none of them holds a market lock in terms of technology standards and features. There is still room for new emerging companies to make their mark in the cloud computing space [22].

2.12. Advantages of Cloud Computing

Cloud computing offers many benefits and flexibility to its users. User can operate from anywhere at any time in a secure way. With the increasing number of web-enabled devices used now-a-days (e.g. tablets, smart phones etc.), access to one’s information and data must be quick and easier. Some of these relevant benefits with respect to the usage of a cloud can be as follows [14]:

- Reduces up-front investment, Total Cost of Ownership (TCO), Total Operational Cost (TOC) and minimizes business risks.
- Provides a dynamic infrastructure that provides reduced cost and improved services with less development and maintenance cost.

- Provides on-demand, flexible, scalable, improved and adaptable services on pay-as-you go model.
- Provides consistent availability and performance with automatically provisioned peak loads.
- Can recover rapidly and has improved restore capabilities for improved business resiliency.
- Provides unlimited processing, storage, networking etc. in an elastic way.
- Offers automatic software updates, Improved Document Format Compatibility and improved compatibility between different operating systems.
- Offers easy group collaboration i.e. flexibility to its users on a global scale to work on the same project.
- Offers increased return on investment of existing assets, freeing capital to deploy strategically.
- Provides environment friendly computing as it only uses the server space required by the application, which in turn reduces the carbon footprints.

2.13. Disadvantages of Cloud Computing.

Every coin has two faces. That's not to say, of course, cloud computing is without disadvantages. Some of the disadvantages while using a cloud can be summarized as [24]:

- Requires high speed network and connectivity constantly.
- Privacy and security is not good. The data and application on a public cloud might not be very secure.
- Disastrous situation are unavoidable and recovery is not possible always. If the cloud loses one's data, the user and the service provider both gets into serious problems.

- Users have external dependency for mission critical applications.
- Requires constantly monitoring and enforcement of service level agreements (SLAs).

2.14. Green cloud computing

The word green in green cloud computing refers to the environment, the classical symbol of the cloud refers to the internet and the short name of the delivery model of the cloud computing is the cloud. The concept of green cloud computing refers to green technologies [26]. Data centers hosting Cloud applications consume massive amount of power, contributing to high carbon footprints to the environment. The amount of the consumed energy is increasing, mainly due to non-energy aware usage of cloud infrastructures [5].

Reducing the energy consumed by datacenters becomes of major importance due to the current climate changes and the increasing success of cloud computing. At the infrastructure level, the energy-efficient scheduling algorithms and memory systems, storage systems as well as the resources management policies are also helpful to EC reduction.

Cloud computing enables organizations to realize great benefits by minimizing operational and administrative costs, it suffers from the problem of high energy consumption that could negate its benefits. Such high energy consumption can lead to an increasing Operational Cost (OC) and consequently reduce the Return on Investment (ROI).

The high energy consumption, apart from the high OC and diminished ROI, results in much carbon dioxide ($CO2$) emissions, which contributes to the global warming. Although advances in physical infrastructure have partly addressed the high energy consumption of datacenters issue, effective resource management is vital in further decreasing the high energy consumption of datacenters.

For instance, hosts in datacenters operate only at 10%-50% utilization for most of the time. As the low utilization of hosts in datacenters results in huge amount of energy wastage, improving host utilization level in the datacenters can help decrease the energy consumption. However, naively improving host utilization level can affect the QoS delivered by the system.

2.15. Open Issues and Challenges in Cloud Computing

Mostly, cloud computing environment relies on virtualization technologies and that offers the capability to hand over VM among physical nodes. It also leads toward the dynamic consolidation in VMs. some open issues are identified and that can be addressed at the level of management of vitality procedures of cloud computing [17, 27].

2.15.1. Dynamic VM Migration

Physical properties could fragment keen on a sum of rational wedges known as VM's. Respectively, virtual machines might provide lodgings a single OS that creates a consumer vision of devoted physical resources. This can confirm routine and incompetent remoteness among VMs distribution as separable physical machines.

The virtualization layer exists among the OS and tools. Besides these outlines, a virtual machine migration (VMM) proceeds to switch the above source as it should remain incorporated of charter's energy organization. Altogether these matters need operational consolidation strategies that can reduce power usage deprived of negotiating the performance.

2.15.2. Resource Utilization

Several VMs are enthusiastically taking place on a particular machine to come across conventional applications. Therefore, there is a need to establish several dividers of resources over a particular physical machine towards particular needs of package applications. Various VMs wanting to execute requests will depend on diverse operating system (OS) situations on a particular physical machine.

Furthermore, with dynamic interchanging VMs through physical machines, idle resources are placed in a manner to minimize the energy phase, shut down or intended to function over minimum energy phases (e.g., with DVFS) to save power resources.

2.15.3. Resource Selection and Provisioning

Energy efficient source collection shows a significant part of cloud computing. Data centers could distribute diverse stages of enactment to the client node. Therefore, it is important to classify mutual behavior, configurations and infer methodologies that can possibly prime towards further resourceful establishment and subsequent power utilization.

2.15.4. Quality of Service

The quality of service provides overall system performance, in particular, importing cloud computing to applications scheduled on a distributed cloud environment. For cloud computing, it is significant to monitor the QoS globally. In the process of resource and task scheduling within a cloud environment, more efforts should be devoted to handling multiple qualities of service requirements from different users [17, 27].

2.15.5. Consolidation of VMs

There is a connection between power usage, resource utilization, and execution of consolidated jobs. The multiple categories of a virtual machine are consolidated on a physical machine server. The virtual machines cannot be interconnected to each other because of fixed or dynamic workloads. With the cooperation of optimization scheduling and inference techniques, power consumption can be optimally utilized [27].

An inference module can be embedded to infer future loads of the system, and then, scheduling algorithms are considered to schedule the expected and unpredicted loads.

2.16. Taxonomy of Power Management Techniques

Energy and power techniques are associated with each other in the management of computing systems. High-level power or energy efficient methods are distributed on static and dynamic energy administration as presented in Figure 2-5.

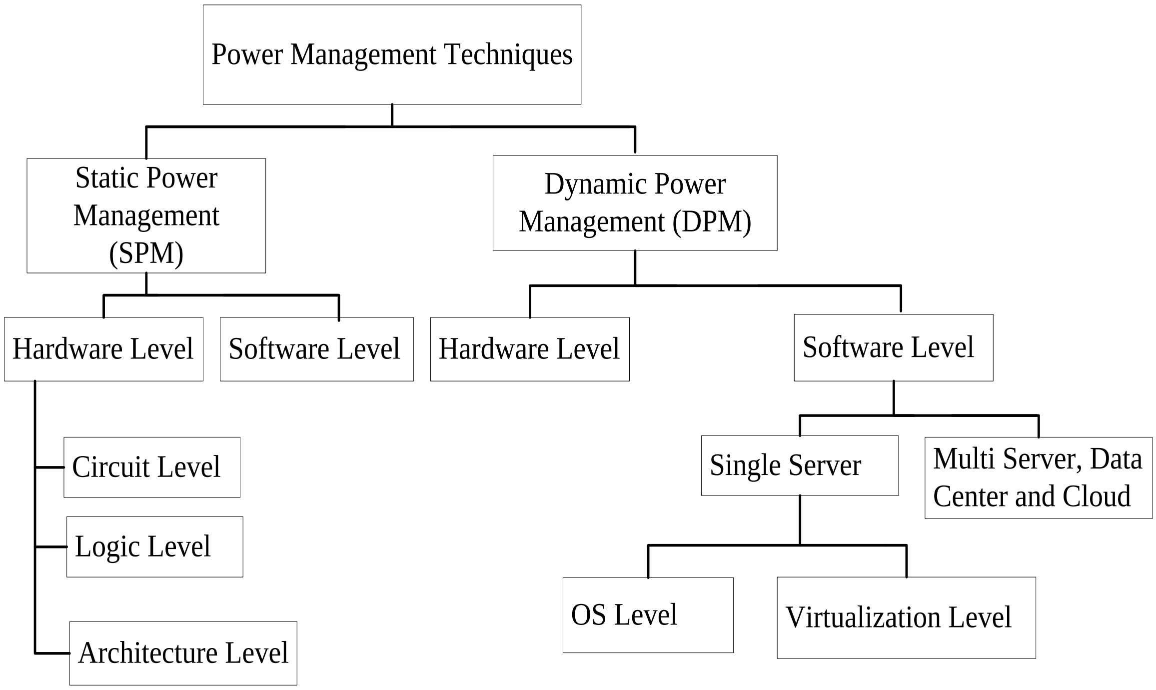

Figure 2-5: High level taxonomy of power management [28]

Static energy administration includes entire streamlining procedures that are connected to the planning phase. DPM methods are eminent by the stratum which they have connected either hardware or software, DPM changes to diverse hardware part. However, generally, it might be delegated as DVS [17, 27].

2.16.1 Hardware Level

Static Power Management (SPM) comprises entire advanced techniques which connected on outlined time with track, design, rationale and framework levels. Track level advancements are centered on the sparing of exchanging actions of specific rational doors and semiconductor level combination tracks by the use of a mind-boggling entry way outline and transistor estimation.

Improvements at the rational point are gone for the switching action force of rational point integration and successive tracks. As shown in Figure 2-6.

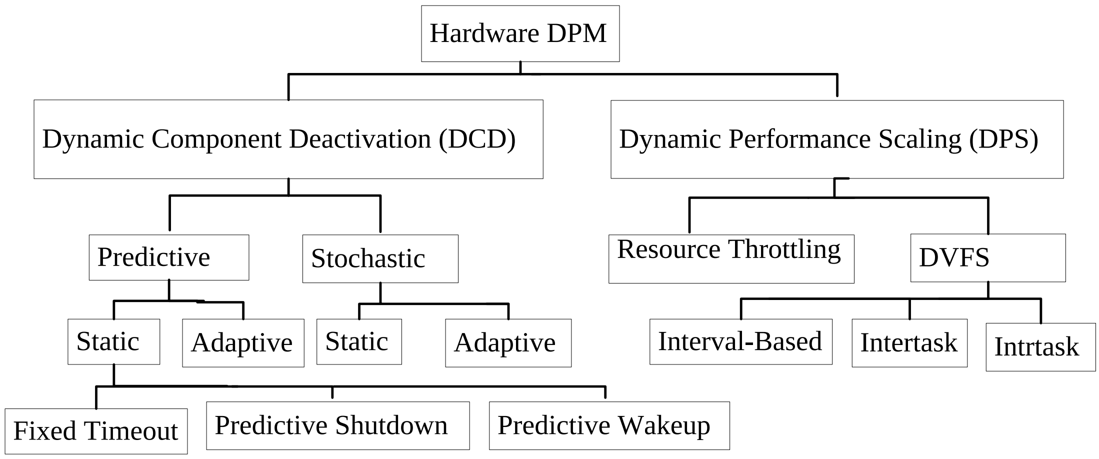

Figure 2-6 : DPM techniques at the hardware levels [28]

DPM techniques could essentially distribute in binary classifications: Dynamic Component Deactivation (DCD) as well as Dynamic Performance Scaling (DPS). Low-power states generally prompt included force utilization and intrusions brought on through the reinstatement of the segments [27].

- Dynamic Component Deactivation (DCD) for PC parts that do procurement execution scaling and must be incapacitated introduces methods that will influence the capability and impair the segment when it is unmoving. The issue is slightly different when accounting for an immaterial move. In all actuality, such moves may take extra energy extraction. Along these lines, to accomplish productivity a movement must be completed just if the unmoving duration is satisfactorily extended to complete the move on time as in Figure 2-6.
- Dynamic Performance Scaling (DPS) includes different techniques that can be applied to computer components supporting dynamic adjustment of their performance proportionally to the power consumption. Instead of complete deactivations, some components, such as CPU, allow gradual reductions or increases of the clock frequency along with the adjustment of the supply voltage in cases when the resource is not utilized for the full capacity. This idea lies in the roots of the widely adopted Dynamic Voltage and Frequency Scaling (DVFS) technique [28] as in figure 2-6.
- Dynamic Voltage and Frequency Scaling (DVFS) regardless of the fact that the CPU recurrence could balance independently, recurrence ascending without anyone else is in-frequently advantageous as an approach to save exchanging forces. Sparing the most power requires dynamic voltage scaling as well, as a result of the V2 part and the way that present-day CPUs are unequivocally upgraded for low voltage states.

DVFS decreases many directions a CPU can dispute in a specified measure phase, hence diminishing the execution. Thus, building executions for system sections that are adequately CPU-bound. This creates difficulties of giving ideal vitality and execution control.

2.16.2. Operating System Level

The examination meets expectations. That is the arrangement with the force effective asset administration at the working framework level .The attributes cast-off to group the mechanism is displayed in Figure 2-5.

2.16.3. Virtualization Level

This assists the generalization of the OS as well as solicitations administration scheduled on or after the HW. There are two methods for how a VMM can take an interest in the force administration. In restricted, a VMM might go about as an OS deprived of qualification among VMs: screen by and large framework's execution. What's more, suitably apply DVFS or any DCD methods to the framework parts. IDC has two sorts of virtualization expertise.

Complete VM, also recognized by way of inbuilt virtualization, usage of a VM which arbitrates among the visitor OS as well as built-in hardware (HW). VMM enables among visitor OS as well as HW. Convinced privileged directions should be confined and controlled inside the VMM since the main hardware is not maintained by the software.

In addition, Para-virtualization is a precise standard method that has about similarities to full virtualization. This procedure of VMM usage aimed at mutual admittance towards original HW, however, assimilates the VM cognizant program towards OS itself. So energy can be preserved.

2.16.4. Data Center Level

The attributes cast-off to characterize the methodologies are exhibited in Figure 2-5. Typically, a methodology is in view of the combining of the workload crosswise over physical hubs in server farms. The workload can be described by approaching solicitations for virtual administrations, network users, or VMs.

The objective is to allow solicitations or VM to the insignificant measure of physical assets and skills or put to rest or snooze expresses the unmoving assets. The issue of the designation is two ways. Initially, it is important to dispense new demands. Second, the execution of existing applications or VMs ought to be persistently observed and if necessary, the portion ought to be adjusted to accomplish the best conceivable vitality proficient exchange off with respect to indicated QoS.

The workload heterogeneity gotten from a genuine cloud environment. They have given the initial approach to evaluate the effect of execution impedance on data centers energy efficiency. Besides, they have introduced an instrument to improve power utilization by misusing the inherent job diversity that occurs in a cloud environment. Outcomes of experiments that demonstrate their suggested component diminishes routinely by 27.5% and builds power utilization up to 15%.

2.17. Related work

Gu in [29] present the Energy cost and carbon emissions focus for cloud operators, two optimization problem: minimizing energy cost and minimizing carbon emissions consider taking the advantages of both ESDs (Energy Storage Devices) and energy trading with the power grid. The reduction is more than 25%in cost for MinCost and 60% in carbon emissions for MinEm. By leveraging larger ESDs, the energy cost and carbon emissions can further be reduced.

Zhao in [26] address the issues of high physical machine (PM) power consumption and virtual machine (VM) performance degradation when placing VMs in the cloud. The experimental results show that PPVMP can reduce PM power consumption and guarantee VM performance compared with other virtual machine placement (VMP) methods. PPVMP is a static VM placement. Once the VMs are placed in a PM, they cannot be migrated on another PMs. VM migration can consume a large amount of bandwidth among PMs.

J. Shayan in [24] investigated the need of power consumption and energy efficiency in cloud computing model. It has been shown that there are few major components of cloud architecture which are responsible for high amount of power dissipation in cloud.

Zhou in [30] puts forward two energy-aware algorithms (KMI-MRCU-1.0 and KMI-MPCU-2.0) based on the adaptive three-threshold framework (ATF), KMI algorithm, VM selection policies (MRCU, MPCU), and maximum energy efficiency placement of VM (VPME) according to the two workload.: 1st regarding the energy efficiency, the algorithm with maximizing the energy efficiency (VPME) has a better performance than the algorithm with minimizing the energy consumption during the placement of VM; 2nd during the selection of a VM, considering both CPU and memory factor is more effective than a single factor such as CPU.

In [31] Usman, proposed energy-efficient VM allocation technique using ISA with aim of reducing datacenter energy consumption and improved the resource utilization of the physical resources. The results show that, the energy consumption of GA and BFD is 90% - 95% as compare to the proposed EE-IS which around 65%. On average 30% of energy has been save using EE-IS as well, the utilization of the resources which has also improved.

In [32] Nagpure, implement a dynamic resource allocation system that avoid overload in server effectively by allocating resource evenly among VMs. The capacity of a physical machine should be sufficient so that it satisfy the resource needs of all virtual machines. Otherwise, physical machine is overloaded and it can decreases performance of virtual machines. used the concept of skewness to calculate the uneven utilization of multiple resources on the server among VMs and checks available server resource and predict future load to avoid overload on server. Proposed work achieve optimize performance in terms of server resource utilization with minimum energy consumption and task migration among VMs.

In [33] Chen, S proposed the quick growth of electricity bill drives owners of data centers to employ server consolidation and the high temperature of data center. However, the traditional air cooling system offers limited benefit of these two approaches due to its low energy efficiency of cooling power especially. We have built a comprehensive framework which covers the costs of server power, cooling power, and hardware maintenance. Based on the models, we introduce a joint optimization of the costs of electricity and server maintenance. The approach gains 23% savings of the total cost and guarantees the response time of more than 96% requests.

2.18. Summary

This chapter defined the cloud computing and its characteristics models, and defined the virtualization and the benefits of virtualization and the advantage and disadvantage of cloud computing. Discussed cloud computing deployment model, services model, infrastructure and Open Issues and Challenges of cloud computing. Explained Taxonomy of energy and power management techniques in cloud computing.

Also, in the related works conclude that the power consumption in cloud computing environment has some deficiency and this would affect the performance enhancement. So need to overcome this limitation by developing an efficient power consumption that consider the reduced power consumption in order to improve the performance of power consumption in cloud computing system.

Chapter Three

Chapter Three

Methodology

3.1. Introductions

This chapter introduce factors to model the power consumption of virtual machine in Physical machine. The methodology was included along with the computer model and the mathematical model used in the simulation; moreover the chapter includes a brief introduction to the requirements and tools used to develop the system, then two scenarios of power consumption done for existing work and proposed work in datacenter.

3.2. Round Robin (R.R)

This policy picks a VM randomly from the group and assigns the VM to a new request. In this strategy, subsequent requests are processed in a rotational order. Each VM is allocated to a request for a fixed interval of time known as time slice. If the request is unable to be finished within the given slice time, it will have to wait for the next cycle to get it turn for execution. This will continue till submitted tasks are completed. Based on this algorithm, there is a modified policy called weighted round robin in which a weight is assigned to each VM depending on the capacity of each VM [34].

3.3. CloudSim

Is the most popular simulation tool available for cloud computing environment [35]. It is an event driven simulator built up on the core of grid simulator GridSim. Base programming language for CloudSim is Java which is one of the famous object oriented programming languages. CloudSim modules are easy to extend as it is based on Java. CloudSim is open source and is free to extend. One unique feature of CloudSim is the federated policy, which is rarely available in any other simulators. CloudSim contains the following features [35]:

- Support modeling and simulation of large scale computing environment.
- A self-contained platform for modeling clouds, service brokers, provisioning and allocation policies.
- Support for simulation of network connections among the simulated system elements.
- Facility for simulation of federated cloud environment that contains inter-network resources from both private and public domains.
- Availability of a virtualization engine that aids in the creation and management of multiple independent and co-hosted virtual services on a data center node.
- Flexibility to switch between spaces shared and time shared allocation of processing cores to virtualized services.
- Despite many features of CloudSim, one major drawback is the lack of Graphical User Interface (GUI) [35].

3.3.1. Major Entities in CloudSim

- Datacenter broker**:** This broker is an agent of VM requests [31]**.** It is designed as an intermediate between cloud users and providers to deploy services over the clouds. It performs dual roles: on one hand, it is primarily responsible for the VM management within a single data center and load balancing of VM's within that single data center; on the other hand, the broker manages the routing of user requests among data centers based on different policies [34].
- Cloudlet: cloudlet A task that actually runs in VM [31]. It is defined for modeling cloud-based application services (e.g.,

content delivery, social networking, and business workflow) in CloudSim. Briefly, a cloudlet is defined as a job or task submitted to cloud. For example if we want to execute a sorting algorithm then the sorting program is the task and in CloudSim there is no need to put the entire file(that contains the sorting program) just have to give the file size, length, input size, and output size [34].

- Cloud Information Service (CIS): This is an entity that provides services such as cloud resource registration, indexing and discovery. The cloud resource table or list (host list, VM list) informs their readiness to process cloudlets by registering themselves. Other entities such as broker can contact CIS to get a list of registered resource IDs for resource discovery service. In analogy, CIS acts like a yellow page service [34].
- Datacenter: data center is Set of physical machine that runs VM[31]. It contains and models hardware and software services in the cloud which is managed by cloud service providers [34].
- Host: Manages the VMs with the help of hypervisor [31]. Host is a computing component of a datacenter. It can host virtual machines and has a defined policy for provisioning CPU, memory and bandwidth to virtual machines [34].
- Virtual Machine (VM): VM is software representation of a physical, every VM must be hosted by host and each VM and host are independent [31].It is not a real machine although it runs inside a host that processes cloudlets. This processing happens according to a policy for submitting cloudlets to VMs to be executed. A host can be used to create multiple virtual machines to interface multiple users [34].

3.3.2. The parameters which are used for implementation

Power Consumption: It is the power consumed by the machine for executing a particular cloudlet or the group of cloudlets [36].

Execution Time: The time in which a single instruction is executed. The execution time or CPU time of a given task is defined as the time spent by the system executing that task, including the time spent executing run-time or system services on its behalf [36].

3.4. Preparing the Programming and Simulation Environment

First of all the CloudSim was downloaded from the official website, then the files was extracted into hard drive say “Drive D” with a free space of 2 GB, and a Memory –Ram not less than 2GB as a hardware requirements and net frame work, java SDK and JDK was installed as a required software, moreover some steps are used to develop a system under Eclipse Java using CloudSim software and libraries.

3.5. Simulation Scenario

The energy efficiency in power consumption has been developed to implement in CloudSim toolkit by using Eclipse. In this new technique cloudlet into multiple conditions submitted to specific VM. First, Broker is created which has functionality of sorting the VM to submit cloudlets to virtual machines. In existing work scenario broker submit cloudlet to VM used time shared data center. So to achieve maximum resource utilization and minimum power consumption the broker sorting VM according to the cloudlet file size to submit cloudlet to VM as in proposed work scenario, that combining task classification scheduling policy for resource utilization of various cloudlet which minimizing the power consumption.

3.6. Evaluation Matrices

In this research an evaluation of the power consumption is the focus using simulation based on CloudSim applied in existing work and proposed work to examine the power consumption variation in datacenters to verified power optimization.

3.7. Proposed Cloud Architecture

Basic architecture of cloud computing for the experimentation used CloudSim simulator. CloudSim setup is done with only one host contains five virtual machines (nodes) and five cloudlet. Figure 3-1 shows the steps of the used methodology.

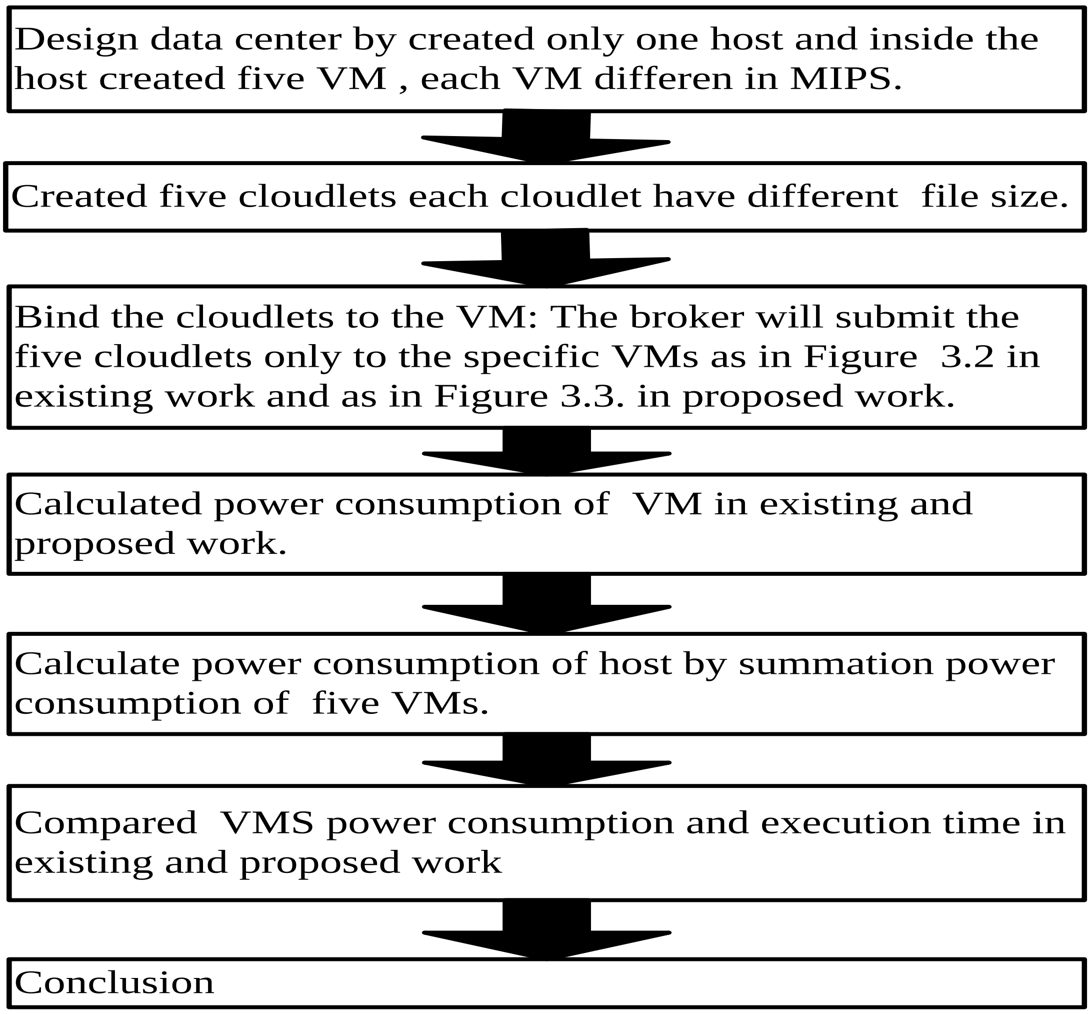

Figure 3-1 Block Diagram of Research Methodology

First step designed data center of only one host included five virtual machines, each virtual machine have different million instruction per second (MIPS). In existing work non-power aware data center applied time shared data center power consumption, that consume all power of data center because five active virtual machine submit to five cloudlet.

To reduced power consumption and enhancement power performance applied proposed work to verified power aware data center by used condition according cloudlet file size the broker submitted cloudlet to virtual machine. To verified that and organized cloudlet divided cloudlet to five range according to cloudlet file size each range have specific condition to selected VM. That reduced wasted resources instead of each cloudlet with small file size submitted VM with large file size as in existing work.

Finally analysis the result of VM power consumption and execution time to understand the effect by compared two results to achieve the objectives of research.

3.8. Energy efficient scheme

To verified energy efficient in cloud computing used two scenarios. In existing work Scenario used time shared data center power consumption, so that the broker submit five cloudlet to five VM discarded cloudlet file size as in Figure 3-2. In proposed work Scenario the condition according cloudlet file size the broker submitted cloudlet to VM as in Figure 3-3.

A virtual machine can be in one of two states, active state, the VM selected by cloudlet and consumed power and idle state, the VM not selected by cloudlet and consumed near-zero of power. The power consumption of a virtual machine mainly depends on the speed (Million Instruction Per Second, MIPS) of the VM as in Equation (3.1)

A_i = (MIPS)^2*10^{-8} J/MI (Joules/Million Instruction) ..….. (3.1) [2]

E_i = (ETV)$_i$* A_i J/MI …………………………….......... (3.2) [2]

Total Energy Consumption (E) =$\sum_{i=1}^{5} E_i$ …………………... (3.3) [2]

Where A_i is the Power consumption of (VM)$_i$ in active state, I_i is the Power consumption of (VM)$_i$ in idle state , (ETV)$_i$ is the execution time of (VM)$_i$,E_i is the energy consumption of (VM)$_i$, which $1 \le i \le 5$.

Then compared power consumed in the proposed algorithm and existing algorithm .

- **Existing Work Scenario**

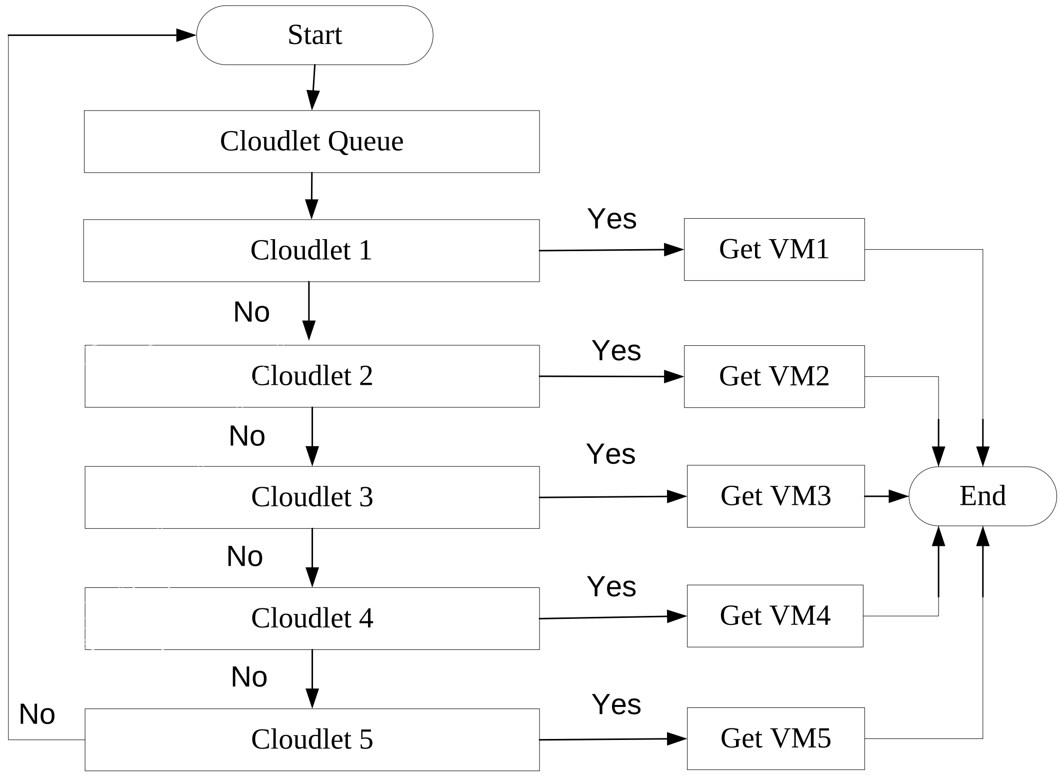

Fig 3-2: Existing Work Scenario

In this scenario non power-aware data center applied time-shared data center power consumption, The data center consume all power of the host. In this scenario the broker submit five cloudlet to five virtual machine (VM) (where the allocation performed randomly, which means any task can be allocated to a VM with 1 = m probability) discarded cloudlet file size as in Figure3.2. And the power consumption of VMs calculated by Equation 3.1, 3.2.

- **Proposed Work Scenario**

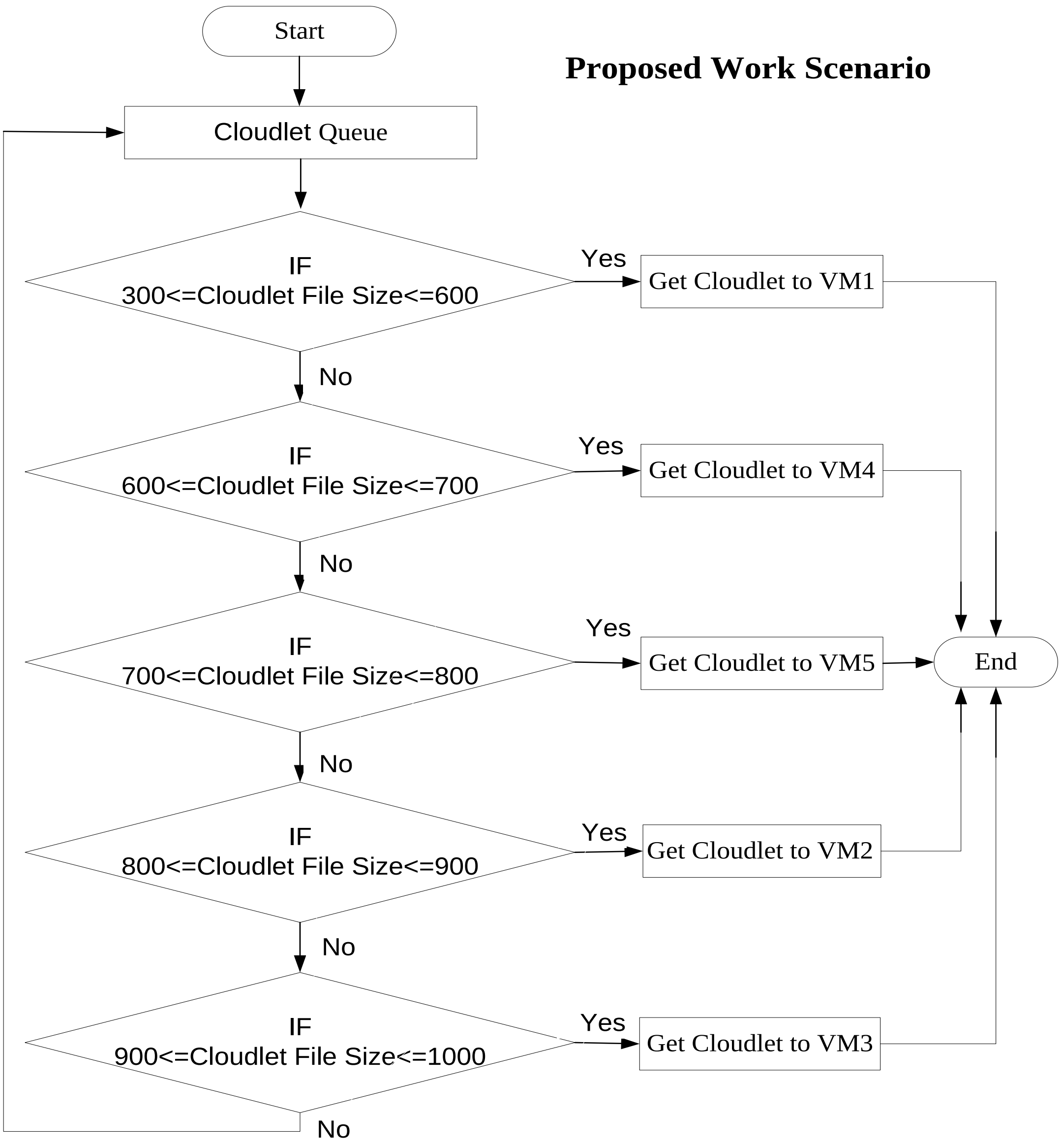

Figure 3-3: Proposed Work scenario

In this scenario power-aware data center, the broker submit cloudlets to VMs according to cloudlet file size with the Round-Robin algorithm (which is the default scheduling algorithm in the CloudSim simulator) as in Figure 3.3, that produced the five cloudlets submit to three VMs, So that cloudlet1, cloudlet2 and cloudlet3 submit to VM1, cloudlet4 submit to VM4 and cloudlet5 submit VM5 but VM2 and VM3 don’t submit by any cloudlet to verified condition of cloudlet file size stayed in idle state, that result VMs arrangement not in order, VM4 become after VM1 and VM5 after VM2. That reduced power consumption by reduced number of active VM .To calculated power consumption of VMs used the equation 3.1,3.2.

Chapter Four

Chapter Four

Results and Discussion

4.1. Introduction

This chapter present, the experiments and results are that done in this research. Then obtained the comparison results of power consumption and execution time in existing and proposed work used time shared data center power consumption in existing work discarded cloudlet file size to submit cloudlet to VM and in proposed work applied specific condition according to cloudlet file size to submit VM. So that the broker submit cloudlet to VM used CloudSim simulator in the implementation.

4.2. Evaluation Scenarios

A java based programming was done to evaluate the performance of the datacenters based on two sub scenarios in the CloudSim simulation/ cloud emulator that is working under the Eclipse java as a library and classes.

The existing work scenario non-power aware data center applied time shared data center discarded cloudlet file size, the broker submit five cloudlets to five VMs. In proposed work scenario power aware data center applied specific condition according cloudlet file size that the broker submit specific cloudlet to specific VM.

In two scenario's calculated power consumption of VMs and execution time, then calculated total power consumption of host.

- **Evaluation of Existing work Scenario**

On time share in the data center the host consume maximum power all the time.

```
========== OUTPUT ==========
Cloudlet ID    STATUS    Data center ID    VM ID    Time    Start Time    Finish Time
    5        SUCCESS          2              5      200       0.1          200.1
    4        SUCCESS          2              4      400       0.1          400.1
    3        SUCCESS          2              3      600.96      0.1          601.06
    2        SUCCESS          2              2      801.28      0.1          801.38
    1        SUCCESS          2              1      1000       0.1          1000.1
Power Consumption by vm1  = 0.625 kwh
Power Consumption by vm2  = 0.783 kwh
Power Consumption by vm3  = 1.043 kwh
Power Consumption by vm4  = 1.563 kwh
Power Consumption by vm5  = 3.125 kwh
The total Power Consumption by Host :
7.138
kwhThe process finished!
```

Figure 4-1: Result of Existing Work Scenario

Table 4-1: Parameters and Results of Existing Work Scenario

Cloudlet		VM		Power Consumption (kwh)	Execution Time (second)
ID	File Size	ID	MIPS		
5	800	5	1250	3.125	200
4	700	4	312.5	1.562	400
3	500	3	416.67	1.041	600.96
2	400	2	625	0.781	801.28
1	300	1	250	0.625	1000
Total Power Consumption				7.134	

Figure 4-1 and Table 4-1show that five cloudlets submitted to five virtual machines, so that VM1 with speed 250 MIPS need 1000 second of time to executed cloudlet1 of 300 file size that consumed 0.625 kwh of power, VM5 with speed 1250 MIPS need 200 second of time to executed cloudlet5 of 800 file size that consumed 3.125 kwh of power. That means there are negative relationship between speed MIPS and execution time of VM. VM power consumption depends on speed MIPS. VM execution time depend on file size of cloudlet and MIPS of VM. In this work non- power aware data center by consumed all power of the host. The host power consumption is the summation of power consumed by five virtual machines that equal to 7.134 kwh.

- **Evaluation of Proposed Work Scenario**

```
========== OUTPUT ==========
Cloudlet ID    STATUS    Data center ID    VM ID    Time     Start Time    Finish Time
    5         SUCCESS        2             5       200        0.1         200.1
    4         SUCCESS        2             4       400        0.1         400.1
    1         SUCCESS        2             1       2999.99        0.1         3000.09
    2         SUCCESS        2             1       2999.99        0.1         3000.09
    3         SUCCESS        2             1       2999.99        0.1         3000.09
Power Consumption by vm1  = 1.875 kwh
Power Consumption by vm4  = 1.563 kwh
Power Consumption by vm5  = 3.125 kwh
The total Power Consumption by Host :
6.562
kwh finished!
```

Figure 4-2: Result of Proposed Work Scenario

Table 4-2: Parameters and Result of Proposed Work Scenario

Cloudlet		VM		Power consumption (kwh)	Execution Time (Second)
ID	File size	ID	MIPS		
5	800	5	1250	3.125	200
4	700	4	312.5	1.562	400
3	500	1	250	1.875	2999.99
2	400				
1	300				
Total Power Consumption				**6.562**	

Figure 4-2 and Table 4-2 show that VM1with speed 250 MIPS executed three cloudlet (cloudlet1, cloudlet2 and cloudlet3) of file size 300,400,500 along 299.99 second of time. VM2, VM3 don’t submit any cloudlet to executed stayed idle .VM4 consumed 1.562 kwh along 400 second and VM5 consumed 3.125 kwh along 200 second. By summation the active VMs power consumption that produced total power consumption of host.

4.3. Comparing results

Table 4-3 Compared result of Execution Time

Cloudlet ID	VM ID	Execution Time	
		Existing working	Proposed working
5	5	200	200
4	4	400	400
3	3	600.96	
2	2	801.28	
1	1	1000	
3	1		2999.99
2			
1			

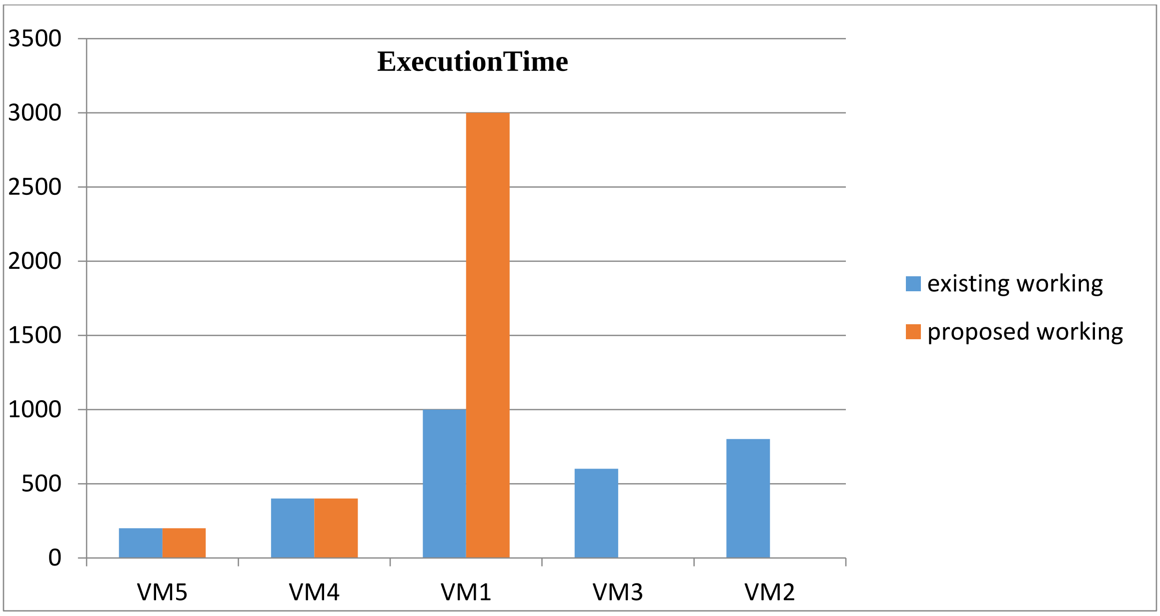

Figure 4-3 Comparison of Execution time

The table 4-3 and the bar chart in figure 433 shows that VM1 execution time in proposed work greater than execution time in existing work so that VM1 in existing work executed one cloudlet(cloudlet1) but in proposed work VM1 executed three cloudlet(cloudlet1,cloudlet2 and cloudlet3) that increased execution time. VM3 and VM4 power consumption equal in two works there is not change. VM2, VM3 don't submit any cloudlet stayed in sleep mode to result zero power consumption.

Table 4-4: Compared Result of Power Consumption

Cloudlet ID	VM ID	VM Power consumption(kwh)	
		Existing work	Proposed work
5	5	3.125	3.125
4	4	1.562	1.562
3	3	1.041	0
2	2	0.781	0
1	1	0.625	1.875

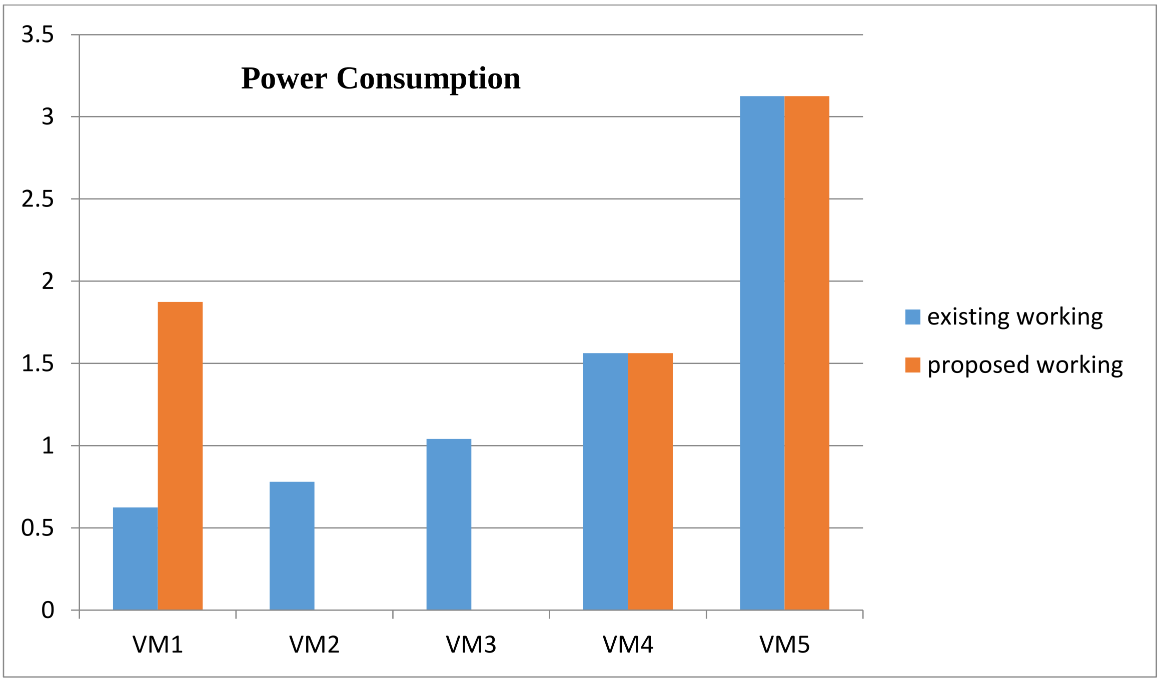

Figure 4-4Comparison Result of Power Consumption

The Table 4-4 and bar chart in Figure 4-4 show that VM1 power consumption in proposed work greater than power consumption in existing work so that VM1 in existing work consumed 0.625 kwh of power to executed one cloudlet (cloudlet1) and VM1 in existing work consumed 1.875 kwh of power to executed three cloudlet (cloudlet1, cloudlet2 and cloudlet3).VM4,VM5 equal in two woks and there is no change in the number of cloudlet.VM2,VM3 no power consumption in proposed work so that VMs in sleep mode no submitted any cloudlet but in existing work consumed power by executed cloudlet2 and cloudlet3.

Table 4-5 Comparison Power consumption of host

Total Power Consumption of Host (kwh)	
Existing work	**Proposed work**
7.134	6.562

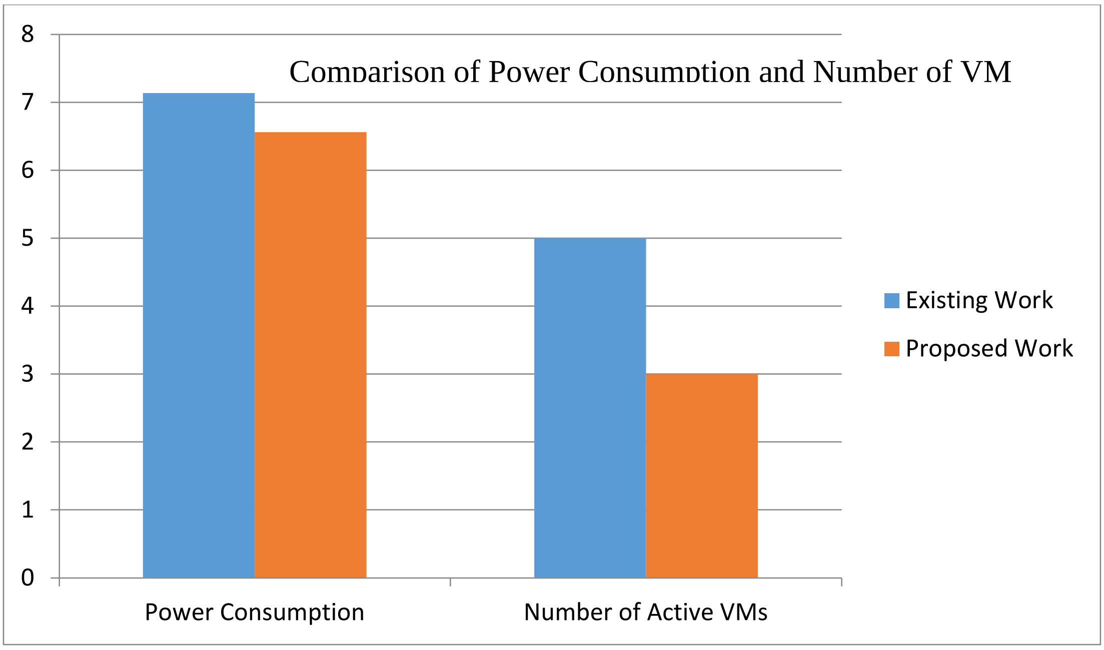

Fig 4-5 Comparison of host power consumption

Table 4-5 and bar chart in Figure 4-5 show that the power consumption in proposed work greater than power consumption in existing work so that number of active VM in proposed work less than number of active VM in existing work that results the positive relationship between total power consumption and number of active VMs.

4.4. Summary

In the first experiment studied the power consumption of virtual machine used two algorithm one of them discarded cloudlet file size in existing work and the other according cloudlet file size in proposed work to select specific VM, the results shown that the virtual machine power consumption in proposed work had a better result of reduced power consumption than virtual machine power consumption in existing work so that the proposed work power aware data center and existing work is non-power aware data center. The cloudlet file size or million instructions (MI) and VM speed MIPS affected negatively to the VM execution time. The reduced of total power consumption in proposed work result of the three cloudlets submitted to one active VM and leave two VM idle, so that if happened in huge data center surely reduced power consumption more and more.

Chapter Five

Chapter Five

Conclusion and Recommendations

5.1 Conclusion

This thesis gives the introduction of Cloud computing and the background of power consumption. The cloud environment is designed or developed in java, deployed on CloudSim toolkit and Experimental results of five cloudlets and five virtual machines have been gathered.

The energy efficiency is one of the major problem in cloud computing. So, in this work efficient energy consumption technique has been proposed. The two factor of cloudlets and VMs which are file size and million instruction per second (MIPS) all of them different in value file size and MIPS, so that file size of cloudlets effect to the execution time and MIPS of VMs effect to power consumption, the execution time and power consumption related to each other and integrated to each other in the calculation of power consumption. Two works, which are existing and proposed works, VMs segment to five VMs: VM1, VM2, VM3, VM4 and VM5, the cloudlet segment to five cloudlets: cloulet1, cloudlet2, cloudlet3, cloudlet4 and cloudlet5, that two work different of condition of VM selection. In existing work scenario applied time share data center that regarded cloudlet file size to select VM, that result five cloudlets get five virtual machines all of them in active state to consumed all power of the host. In proposed work scenario applied intelligent distribution of cloudlet that according cloudlet file size get VM, that result five cloudlet select three virtual machines in active state and two virtual machines in idle state that reduced power consumption of the host by reduced number of active VMs. So the proposed work scenario is energy efficient and power aware datacenter.

5.2. Recommendations

- Use Power Prediction algorithm to enhance the time shared data center.
- Compare scheduling algorithms with time shared data center method.
- To be aware that reduction of power consumption will not waste in VM selection method.
- Implement a graphical user interface to simplify the use of the CloudSim with Eclipse.

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Appendix

Java Code of Proposed Work

```
public class ftest {
private static PowerModel powerModel;
/** The cloudlet list. */
private static List<Cloudlet> cloudletList;
/** The vmlist. */
private static List<Vm> vmlist;
/**
 * Creates main() to run this example
 * @param object
*/
public double getPower() {
return getPower(getUtilizationOfCpu());
}
private double getPower(Object utilizationOfCpu) {
// TODO Auto-generated method stub
return 0;
}
private Object getUtilizationOfCpu() {
// TODO Auto-generated method stub
return null;
}
protected double getPower(double utilization) {
double power = 0;
try {
power = getPowerModel().getPower(utilization);
```

```
} catch (Exception e) {
e.printStackTrace();
System.exit(0);
}
return power;
}
public double getMaxPower() {
double power = 0;
try {
power = getPowerModel().getPower(1);
} catch (Exception e) {
e.printStackTrace();
System.exit(0);
}
return power;
}
public double getEnergyLinearInterpolation(double fromUtilization,
double toUtilization, double time) {
if (fromUtilization == 0) {
return 0;
}
double fromPower = getPower(fromUtilization);
double toPower = getPower(toUtilization);
return (fromPower + (toPower - fromPower) / 2) * time;
}
public static void main(String[] args) {
Log.printLine("Starting ...");
try {
Calendar calendar = Calendar.getInstance();
```

```
boolean trace_flag = false;  // mean trace events
int num_user = 0;
CloudSim.init(num_user, calendar, trace_flag);
@SuppressWarnings("unused")
Datacenter datacenter0 = createDatacenter("Datacenter_0");
DatacenterBroker broker = createBroker();
int brokerId = broker.getId();
vmlist = new ArrayList<Vm>();
//VM description
int vmid = 1;
int mips = 1250;
long size = 10000;        //image size (MB)
int ram = 512;            //vm memory (MB)
long bw = 1000;
int pesNumber = 1;        //number of cpus
String vmm = "Xen";       //VMM name
//create  VMs
Vm vm1 = new Vm(vmid, brokerId, mips /5, pesNumber, ram, bw,
size, vmm, new CloudletSchedulerTimeShared());
int power1 = mips * mips / 100000000;
vmid++;
Vm vm2 = new Vm(vmid, brokerId, mips /4, pesNumber, ram, bw,
size, vmm, new CloudletSchedulerTimeShared());
int power2 = mips * mips / 100000000;
vmid++;
Vm vm3 = new Vm(vmid, brokerId, mips /3, pesNumber, ram, bw,
size, vmm, new CloudletSchedulerTimeShared());
int power3 = mips * mips / 100000000;
vmid++;
```

```
Vm vm4 = new Vm(vmid, brokerId, mips /2, pesNumber, ram, bw,
size, vmm, new CloudletSchedulerTimeShared());
int power4 = mips * mips / 100000000;
vmid++;
Vm vm5 = new Vm(vmid, brokerId, mips, pesNumber, ram, bw,
size, vmm, new CloudletSchedulerTimeShared());
int power5 = mips * mips / 100000000;
//add the VMs to the vmList
vmlist.add(vm1);
vmlist.add(vm2);
vmlist.add(vm3);
vmlist.add(vm4);
vmlist.add(vm5);
//submit vm list to the broker
broker.submitVmList(vmlist);
cloudletList = new ArrayList<Cloudlet>();
//Cloudlet properties
int id = 1;
pesNumber=1;
long length = 250000;
long fileSize = 1500;
long outputSize = 300;
UtilizationModel utilizationModel = new UtilizationModelFull();
Cloudlet cloudlet1 = new Cloudlet(id, length, pesNumber, fileSize =
300, outputSize, utilizationModel, utilizationModel, utilizationModel);
cloudlet1.setUserId(brokerId);
id++;
Cloudlet cloudlet2 = new Cloudlet(id, length, pesNumber, fileSize =
400, outputSize, utilizationModel, utilizationModel, utilizationModel);
```

```
cloudlet2.setUserId(brokerId);
id++;
Cloudlet cloudlet3 = new Cloudlet(id, length, pesNumber, fileSize =
500, outputSize, utilizationModel, utilizationModel, utilizationModel);
cloudlet3.setUserId(brokerId);
id++;
Cloudlet cloudlet4 = new Cloudlet(id, length, pesNumber, fileSize =
700, outputSize, utilizationModel, utilizationModel, utilizationModel);
cloudlet4.setUserId(brokerId);
id++;
Cloudlet cloudlet5 = new Cloudlet(id, length, pesNumber, fileSize =
800, outputSize, utilizationModel, utilizationModel, utilizationModel);
cloudlet5.setUserId(brokerId);
//add the cloudlets to the list
cloudletList.add(cloudlet1);
cloudletList.add(cloudlet2);
cloudletList.add(cloudlet3);
cloudletList.add(cloudlet4);
cloudletList.add(cloudlet5);
//submit cloudlet list to the broker
broker.submitCloudletList(cloudletList);
bind the cloudlets to the vms. This way, the broker
if(fileSize <= 300 || fileSize >= 600) {
broker.bindCloudletToVm(cloudlet1.getCloudletId(),vm1.getId());
broker.bindCloudletToVm(cloudlet2.getCloudletId(),vm1.getId());
broker.bindCloudletToVm(cloudlet3.getCloudletId(),vm1.getId());
}
else
if(fileSize <= 800 || fileSize >= 900) {
```

```
broker.bindCloudletToVm(cloudlet1.getCloudletId(),vm2.getId());
broker.bindCloudletToVm(cloudlet2.getCloudletId(),vm2.getId());
broker.bindCloudletToVm(cloudlet3.getCloudletId(),vm2.getId());
}
else
if(fileSize <= 900 || fileSize >= 1000) {
broker.bindCloudletToVm(cloudlet1.getCloudletId(),vm3.getId());
broker.bindCloudletToVm(cloudlet3.getCloudletId(),vm3.getId());
}
else
if(fileSize >= 600 & fileSize <= 700) {
broker.bindCloudletToVm(cloudlet4.getCloudletId(),vm4.getId());
}
else
if(fileSize >= 700 & fileSize <= 800) {
broker.bindCloudletToVm(cloudlet5.getCloudletId(),vm5.getId());
}
// Starts the simulation
CloudSim.startSimulation();
//  Print results when simulation is over
List<Cloudlet> newList = broker.getCloudletReceivedList();
CloudSim.stopSimulation();
printCloudletList(newList);
Log.printLine(" finished!");
}
catch (Exception e) {
e.printStackTrace();
Log.printLine("The simulation has been terminated due to an unexpected
error");
```

```
}
private static Datacenter createDatacenter(String name){
List<Host> hostList = new ArrayList<Host>();
List<Pe> peList = new ArrayList<Pe>();
int mips = 10000;
peList.add(new Pe(0, new PeProvisionerSimple(mips)));    // need to
store Pe id and MIPS Rating
// Create Host with its id and list of PEs and add them to the list of
machines
int hostId=0;
int ram = 16384;                //host memory (MB)
long storage = 1000000;         //host storage
int bw = 100000;
PowerModel  powerModel = null;
hostList.add(
new Host(
hostId,
new RamProvisionerSimple(ram),
new BwProvisionerSimple(bw),
storage,
peList,
new VmSchedulerTimeShared(peList)
)
);
setPowerModel(powerModel);
// This is our machine
String arch = "x86";             // system architecture
String os = "Linux";             // operating system
String vmm = "Xen";
```

```
double time_zone = 10.0;        // time zone this resource located
double cost = 3.0;              // the cost of using processing in this resource
double costPerMem = 0.05; // the cost of using memory in this resource
double costPerStorage = 0.001; //the cost of using storage in this
resource
double costPerBw = 0.0;  // the cost of using bw in this resource
LinkedList<Storage> storageList = new LinkedList<Storage>();
//we are not adding SAN devices by now DatacenterCharacteristics
characteristics = new DatacenterCharacteristics(arch, os, vmm, hostList,
time_zone, cost, costPerMem, costPerStorage, costPerBw);
Datacenter datacenter = null;
try {
datacenter = new Datacenter(name, characteristics, new
VmAllocationPolicySimple(hostList), storageList, 0);
} catch (Exception e) {
e.printStackTrace();
}
return datacenter;
}
private static void setPowerModel(PowerModel powerModel2) {
// TODO Auto-generated method stub
}
private static DatacenterBroker createBroker(){
DatacenterBroker broker = null;
try {
broker = new DatacenterBroker("Broker");
} catch (Exception e) {
e.printStackTrace();
return null;
```

```
}
return broker;
}
/**
* Prints the Cloudlet objects
* @param list  list of Cloudlets
*/
private static void printCloudletList(List<Cloudlet> list) {
int size = list.size();
Cloudlet cloudlet;
String indent = "    ";
Log.printLine();
Log.printLine("========== OUTPUT ==========");
Log.printLine("Cloudlet ID" + indent + "STATUS" + indent + "Data
center ID" + indent + "VM ID" + indent + "Time" + indent + "Start
Time" + indent + "Finish Time
DecimalFormat dft = new DecimalFormat("###.##");
for (int i = 0; i < size; i++) {
cloudlet = list.get(i);
Log.print(indent + cloudlet.getCloudletId() + indent + indent);
 if (cloudlet.getCloudletStatus() == Cloudlet.SUCCESS){
Log.print("SUCCESS");
Log.printLine( indent + indent + cloudlet.getResourceId() + indent +
indent + indent + cloudlet.getVmId() + indent + indent +
dft.format(cloudlet.getActualCPUTime()) + indent + indent +
dft.format(cloudlet.getExecStartTime())+ indent + indent +
dft.format(cloudlet.getFinishTime()));
public static PowerModel getPowerModel() {
return powerModel;}
```