SIMULATION OF ALGORITHMS AND TECHNIQUES FOR GREEN CLOUD COMPUTING USING CLOUDANALYST

A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF APPLIED SCIENCES

OF

NEAR EAST UNIVERSITY

By

HASAN RAFE HASAN QARQUR

In Partial Fulfillment of the Requirement for the Degree of Master of Science

In

Software Engineering

NICOSIA, 2020

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Approval of Director of Graduate School of Applied sciences

Prof.Dr.Nadire CAVUS

We certify this thesis is satisfactory for the award of the degree of Master of Science in Software Engineering

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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I would like to thank all people who supported me in my master degree journey and I would like to give a special thanks and prayers to my father the consultant Rafe Qarqur and to my mother Huda Al-Saadi for their continuous support, and never forget the extreme support and fully guidance from my dear supervisor Assoc. Prof. Dr.Melike Şah Direkoğlu and her efforts in helping me to write this thesis in the right way, and I would like to thank my chairperson Assoc. Prof. Dr.Yöney Kırsal EVER and my advisor Assist. Prof. Dr. Boran ŞEKEROĞLU who guided my through my duration of study, and never forget Prof. Dr.Nadire ÇAVUŞ for her efforts in teaching me, As well I would like to thank our principle for giving me the chance to study and research in our beautiful university NEU, and I will not forget to thank my colleagues at middle east international office who helped me and gave me the facilities to accomplish my thesis.

To my parents...

ABSTRACT

In our fast growing world and with the synchronization of the fourth industrial revolution, the cloud computing took place and became a milestone of industrial revolution. The cloud computing offers online services, wherever and whenever the user requests. The most of the leading companies in our world like Microsoft, Google and Amazon have contributions for development of this field and they offer their services to users, companies and organization by cloud computing. Like infrastructure services, Platform services, software services and network services. Because of the importance of cloud computing and maintaining the service sustainable and reliable, the data centers which deployed all over the world have to work continuously and efficiency .This is led to high electrical power consumption and big emission of CO_2, As a result the concept of green cloud computing (GCC) has appeared and took the interest of providers of services, researchers and end users. On the other hand many algorithms took care about reducing the power consumption and carbon emission. In this thesis I presented many algorithms and chose some of them to simulate the datacenters. We had simulated 7 datacenters in different regions with 7 users and ten requests per user per hour, during a period of one year. We had results of this simulation and we compared them to find out the best algorithm to use. Also tabulated the results and showed in charts the simulation results of nine cases. Also advised the reader to use a specific algorithm for continues and sustainable performance.

Keywords: Cloud Computing; Green Cloud Computing; Datacenters; Algorithms of GCC; Simulation of Datacenters; Power Reduction

ÖZET

Hızlı büyüyen dünyamızda ve dördüncü sanayi devriminin senkronizasyonu ile bulut bilişim gerçekleşti ve bir sanayi devriminin dönüm noktası oldu. Bulut bilişim, kullanıcının istediği yerde ve zamanda çevrimiçi hizmetler sunar. Microsoft, Google ve Amazon gibi dünyamızın önde gelen şirketlerinin çoğunun bu alanın geliştirilmesine katkıları vardır ve hizmetlerini bulut bilişim yoluyla kullanıcılara, şirketlere ve kuruluşlara sunmaktadırlar. Altyapı hizmetleri, Platform hizmetleri, yazılım hizmetleri ve ağ hizmetleri gibi. Bulut bilişimin ve hizmetin sürdürülebilir ve güvenilir tutulmasının önemi nedeniyle, tüm dünyaya dağıtılan veri merkezleri sürekli çalışmak ve verimlilik sağlamak zorundadır.Bu yüksek elektrik güç tüketimine ve büyük CO2 emisyonuna yol açmaktadır. yeşil bulut bilişim (GCC) 'nin ortaya çıktığı ve hizmet sağlayıcıların, araştırmacıların ve son kullanıcıların ilgisini çekti. Diğer yandan birçok algoritma güç tüketimini ve karbon emisyonunu azaltmaya özen gösterdi. Bu tezde birçok algoritma sundum ve bazılarını veri merkezlerini simüle etmek için seçtim. Bir yıl boyunca, farklı bölgelerde 7 veri merkeziyle 7 kullanıcı ve saatte kullanıcı başına on istek ile simüle ettik. Bu simülasyonun sonuçlarını aldık ve kullanılacak en iyi algoritmayı bulmak için bunları karşılaştırdık. Ayrıca sonuçları tablo haline getirildi ve dokuz vakanın simülasyon sonuçlarını grafiklerde gösterildi. Ayrıca okuyucuya sürekli ve sürdürülebilir performans için belirli bir algoritma kullanmasını tavsiye edildi.

Anahtar Kelimeler: bulut bilişim; yeşil bulut bilişim; Veri merkezleri; GCCAlgoritmaları; Veri Merkezlerinin Simülasyonu; güç azaltma

TABLE OF CONTENTS

CHAPTER 4

ALGORTHIMS USED IN GCC TO REDUCE ENERGY CONSUMPTION

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ICTs :	communication technologies
SDLC :	software development life cycle
SaaS :	Software as a service
IaaS :	Infrastructure as a service
PaaS :	Platform as a service
SLA :	service level agreement
GCC :	Green Cloud Computing
CCS :	carbon capture and storage
QoS :	the quality of service
PM :	physical machine
VMs :	virtual machines
MIPS :	million instruction per second
NN :	neural network
CC :	cloud computing
DVFS :	Dynamic voltage frequency scaling
FDT :	Feedback driven threading
EGS :	Enhanced Geothermal System
NUTS :	a Non-Urgent & Urgent Task Scheduling
DC :	Datacenter
DAPSO :	Dynamic Adaptive Particle Swarm Optimization
PSO :	Particle Swarm Optimization algorithm
ACO :	Ant Colony
CS :	Cuckoo search
SQ :	hold new task, critical task and waiting for task demons for scheduling
NCTQ :	holds task that is not completed in SQ
EEDD :	Energy-efficient data delivery algorithm
MDAPSO:	Mdapsotask Scheduling Algorithm

PSOCS : Merge of PSO algorithm with the Cuckoo Search (CS) algorithm

CHAPTER 1

INTRODUCTION OF GREEN CLOUD COMPUTING

1.1 Introduction of Cloud Computing

Cloud computing is a subfield of information and communication technologies (ICTs), brings new challenges for environment conservation. Cloud computing offers various services, which includes sustainable and reliable cloud computing with high performance and low price. With the new demands of cloud computing the networking has improved. In addition a new concept of green cloud computing which deal with environment protection and conservation with cloud computing services also offers cloud computing services with low costs which enhances the economy, and leads to decrease of e-wastes and carbon footprints.

Sustainability is very important in both software and hardware for both users and developers. Because of increasing demand on power energy, As a result the effect of information and technologies (ICTs) on environment in software development life cycle (SDLC) has been considered. In order to develop a green technology, which conserves energy, reduces carbon dioxide footprint and lower the entire costs of services. There is a pressure on cloud computing operating to engage the environmental regulations and to optimize their services to meet the minimum requirements of eco-environment regulations system, As in sequence decisions made considering the sustainable of (ICTs) as well as considering the effects of (ICTs) on environment now and in future.

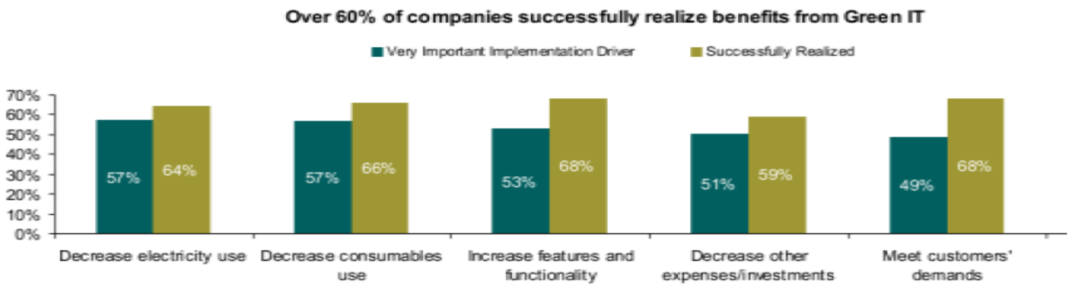

Figure 1.1.1: More than 60% of companies and users successfully being benefited from Green computing technologies

1.2 Cloud Computing the Overview

Nowadays, cloud computing become a millstone of available technologies, since it offers access to complex applications and data resources, without requiring extensive computing resources. There are many concepts in cloud computing like virtualization, parallel computing and distributed computing. And some other new like micro service and grid computing. The cloud computing concept is improving continuously field in sides, software and hardware. There are three main models of cloud computing which are:

- Software as a service (SaaS).
- Infrastructure as a service (IaaS).
- Stand as a service (PaaS).

Figure 1.1.2.1: Illustrates the cloud computing main services

IaaS and PaaS are provided to stakeholders, developer and organizations, but SaaS provided are to the end users. We can divide the cloud to three parts as shown below.

Figure 1.2.2: Types of cloud computing

The datacenter could be identified as shared space of computing and communication resources arranged in a way to utilize the power energy into computing processes or demanded users. And this is referring to energy utilization efficiently of the IaaS model. SaaS as well support benefits for environmental conservation. By concentration of processing and service sharing, it aggregated datacenter processes to use less tools and devices, software as service providers can support users with green and environment friendly services. That spread over environment friendly datacenters and using algorithms to reduce energy consumption, carbon emission, and keep the sustainability and reliability to meet the (SLA) service level agreement. When we talk about providers, we note that they have more interest to invest in green technology because of the high efficiency obtained and the reduction in energy costs.

1.3 Green Cloud Computing GCC

1.3.1 A brief statistics of GCC

The improving in Green Cloud Computing (GCC), is related to the development of green data centers, since the datacenters are the cradle of Cloud computing. The consumption of electrical energy by datacenters in the year 2010 represented 1.5% of the total energy consumption in United States of America, where the consumption of energy of the United States is approximately the quarter consumption of the world. While the carbon dioxide an emission from (ICTs) consists of 1.3% of the world emission in 2002 and will be approximately 2.3 % of the global emission in 2020. The carbon dioxide (CO_2) reservation known as (CCS) carbon capture and storage, about one over third (1/3) of Co_2 emissions should be decreased by the 2050, as the International Energy Authority states, the emissions of CO_2 from this plant must be 90% less than the normal facilities. The green IT concept spread worldwide and took the consideration of many researcher, developer and organizations, to reduce the electrical power consumption and carbon emissions resulted to reduction of the cost.

Figure 1.3.1: Carbon dioxide emissions

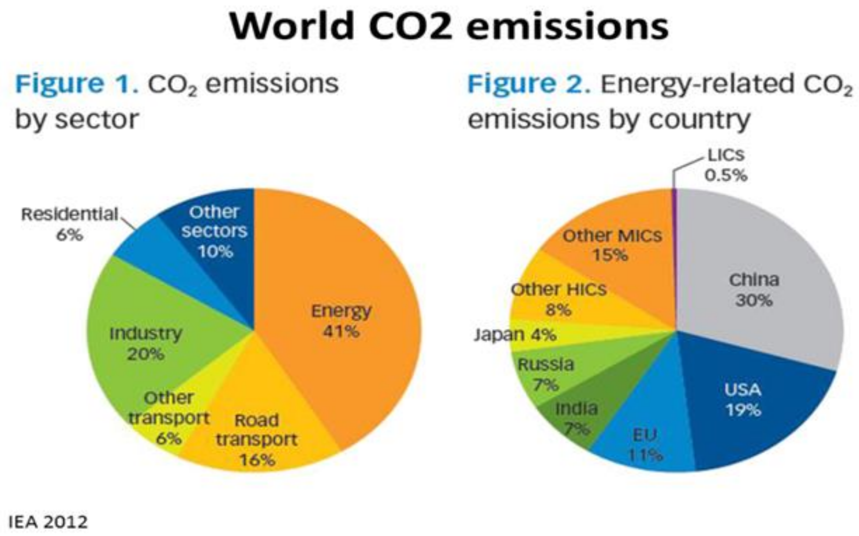

Figure 1.3.2: Shows the world CO2 emissions

The interests of GCC studies and the impact of GCC on environment received by GCC community which is the report published by Gartner (Mingay, S, 2007) which stated the global ICTs is responsible of 2% of global carbon dioxide emission in 2009. So the new architecture of green cloud computing GCC which aiming to decrease the electrical power consumption and the CO2 emission of the datacenter. The studies were very important since it improved the cloud computing. The efficiency of datacenters optimized and the carbon emissions and e-wastes were minimized. Not only for the ICTs but for all other aspects like (buildings, cooling, lighting, etc.). If we overview the green computing concept, we will find that it is not related to energy consumption of computers only but as well includes the cooling systems, networking systems, etc. The improvement of researches took a place of interest by the increasing care of environment by governments and environment friendly organizations, figure 1.6 below illustrate the growth of interest of green cloud computing in the academic field between the years of 2009 to 2016.

1.3.2 Research on GCC

To investigate the GCC field, first existing research has analyzed as in figure 1.6.

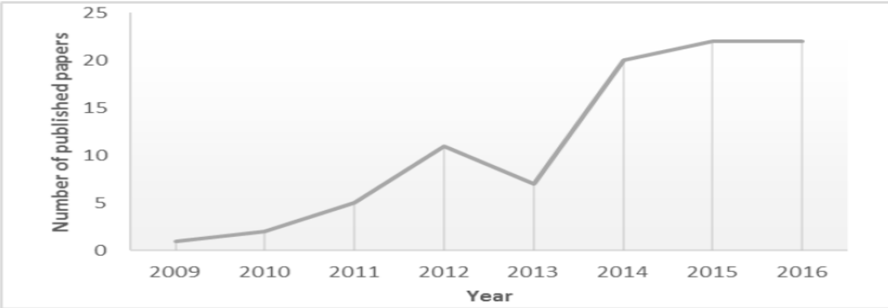

Figure 1. 1.3.3: Illustrates the distribution of surveys over years

The improvement of GCC is performed by the efficient usage of resources and the right power management , so that results in reduced of power electrical consumption and carbon dioxide emission, which will reduce the costs of transferring data and the overall cost of using cloud computing. In GCC research field, the most studied subject is the optimization of consumed energy using the power or resource management.

1.4 Aims and Objectives

This research focuses on reducing the power consumption of Cloud Computing Datacenters which knowns as GCC. We aimed to reduce power energy by reducing the response time between the user demand requests and receiving the service. This will result to reduce the total energy consumption in datacenter and transferring network. Our main objective is to simulate the datacenter using various algorithms to find out the best method to reduce the response time and the total cost by sequence.

1.5 Motivations

The main motivation to do this research was the passion and the necessity to reduce the power energy used by datacenters and the carbon dioxide emissions, with sustain the cloud computing services working efficient, sustainable and reliable way. That will results and contributes in environment conservation and will lower the operation costs of cloud computing service

CHAPTER 2

LITERATURE REVIEW OF GREEN CLOUD COMPUTING

2.1 GCC Structure

According to (Kliazovich et al, 2012) GCC could be divided into five main categories such as Algorithms, Architectures, Frameworks, General Issues, Models and Methods. And the most studied topic is the optimization of energy consumption, then resource management. Effective resource management is going to develop GCC by reducing energy consumption, electronic wastes and costs. Fortunately, some factors which providers of cloud computing will be benefited from. Such as reduces energy consumption, costs and carbon dioxide emissions. According to (Federico et, al, 2013) he proposed a technique to develop the network design to enhance the quality of service QoS, and simultaneously decreasing the costs and the consumumption of electrıcal energy. The presented technique 'tabu' is going to decrease the overload on datacenters via a condition called penalty in the objective function, and still repeating the process to find the suitable solution. Demands are given by user changing frequently, so the process should be studied, and the currently methods which utilized in hosts and datacenters, development of the 'tabu' technique, which presented an intervention conscious emigration. On other hand the selection of virtual machine is performed by decision process and the chosen virtual machine should be migrated to the proper physical machine PM. In order to decrease both virtual machine emigration intervention and shared site intervention. This method improved by using intervention conscious of virtual machine live-emigration technique and multiple resource request outfit model. Which will reduce the performance intervention while and after emigration of virtual machines. And this feature could be applied to various physical machines as only DCs with identical PMs.

Bei proposed an aware of communication scheduling in (Bei et al, 2014) to decrease the shared location interference of virtual machines response time. The communication of interference VMs operates over the same virtualization platform. The approach has studied only the virtualization platform, but the effect of other platforms should be assessed. The network communication between the migrating VMs and VMs on the original PMs and the architecture of multi-core systems should be studied for a better solution.

The provided approach in (Zhu et al, 2014) of real time jobs where scheduled and put in high priority to finish the jobs. Also more virtual machines added and in case of idle hosts the aggregation is performed to improve the usage of resources. The presented model develops the scheduled quality which could be better if more other metrics could be studied to build a power model as the mentioned method. It takes the energy consumption of the processor apart from building the energy model. Scheduling plan has been improved with the 2-stage virtual machine, which composed of the static virtual machine status plan and the variable virtual machine emigration plan. In order to test the energy performance tradeoff in infrastructure as service cloud.

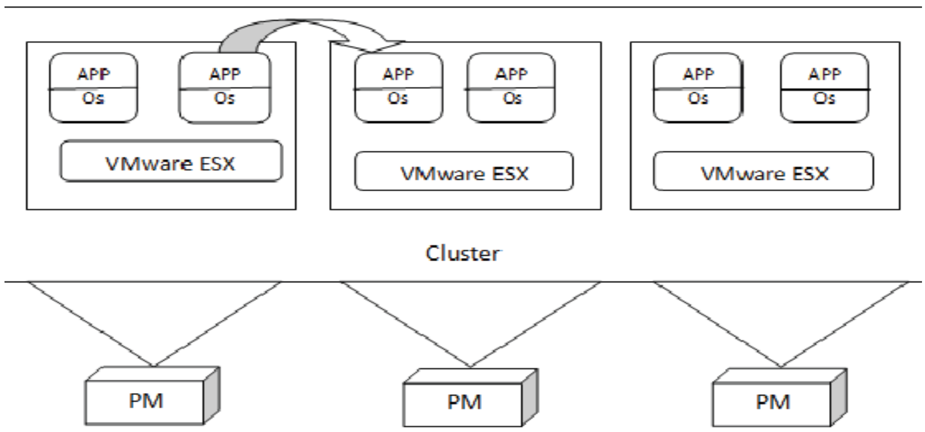

Figure 2.1.1: Two stage virtual machine migration

Figure 2.1.1 shows the workloads running procedure flow for the architecture of green Cloud computing .The DCs and information of cloud service offers computing service to users of cloud who submit their load of data to the datacenter's brokers as shown below in sequence.

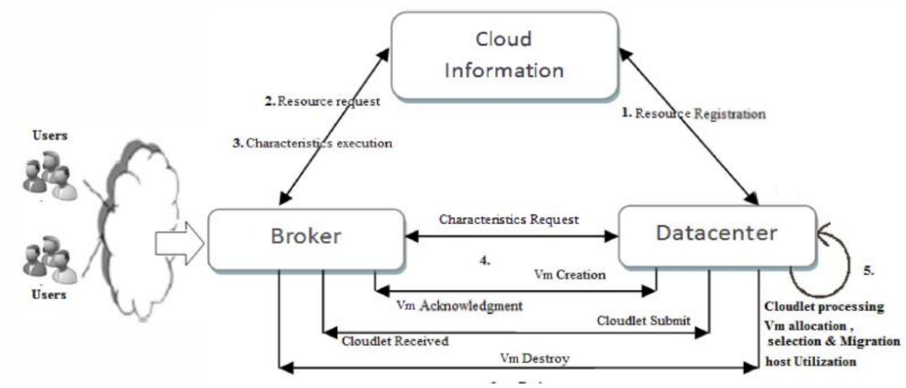

Figure 2.1.2: Shows the system model and working flow

DC is consists of a group of many operating servers, which are utilized to handle the work load. Through the VMs, the workloads are being submitted; as well the process of recording the workloads is being performed to be used later in prediction process to make decision on creating and ruining the virtual machines in servers. Also migrating them and switching servers (on) or (off) to handling cloudlets.

Virtual machine situation and allocation process could be explained as the following:

- Virtual machine status: Virtual machine supplying for new demands and new situations on hosts.
- The optimization of allocation of currently virtual machine pointed by determining the over utilized host.
- Virtual machine determination policy: to select which virtual machine should be migrated.

After the determination of virtual machine which will migrate, the host put to check again to avoid the overload .But if appears that the host is overloaded, another Virtual machine should be selected. The Virtual Machine emigration number is the Virtual machines number of emigration because of over/under utilization of the host. Turned off numbers, is the number of times that the nodes switched to idle. Running time, is the time of virtual machine reallocation so the mean could be calculated from the running time history of reallocation of virtual machines saved by the allocation log history.

2.2 GCC Power Managements

The consumption energy is not determined only by the efficiency of equipment, but as well it is based on the management of system resources. That is spread on the basic physical, organizational structures and facilities. Also the quality of software which operates on cloud and the method of finding solutions of cloud computing problems, and optimizing the efficiency to the maximum are all factors should be considered to improve the efficiency. On other hand, we proposed an improvement in power efficiency by 40% more than other strategies.

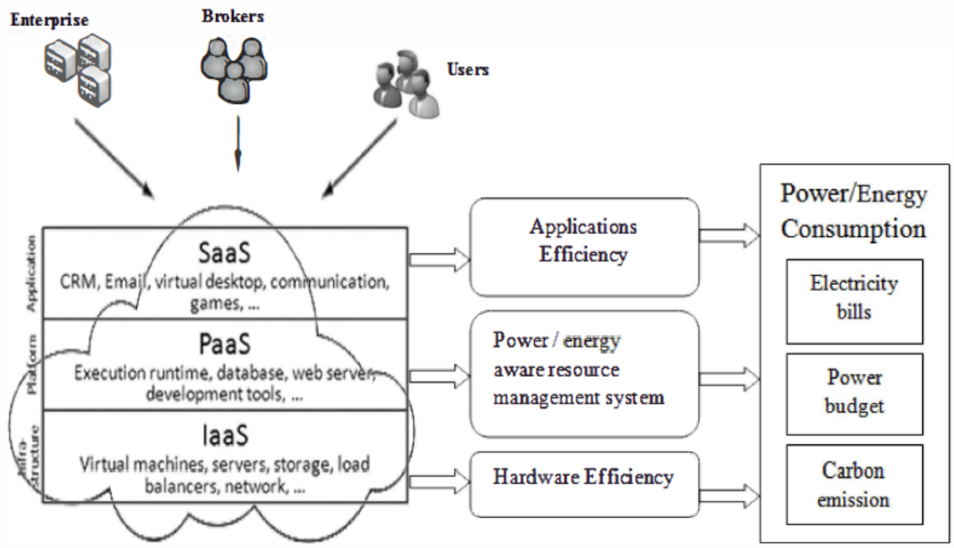

Figure 2.2.1: Cloud topology and the impact of Cloud Computing

There are a lot of problems facing the conservation of energy and costs. Such as scalability, flexibility, maintainability, reliability, security and geographical location. So we need green smart solutions. One of challenges is applying the methods and strategies without violating the service level agreement SLA and keeps energy consumption in the minimum rates. Beloglazovt and Buyya proposed in [Beloglazovet al, 2011] a version of adaptive heuristics and biases for dynamic aggregation of virtual machines. Depending on analyzing data out of resource usage by virtual machine which decreases the consumption of energy while assuring the service level agreement SLA is maintained.

Ramezani in (Ramezani and Hussain, 2013) proposed the management of an internet technique of resources, which enhances the system that locates tasks schedule and optimization of management of resources in a single system. And it uses the prediction of fuzzy model as a technique to predict virtual machine workload behavior and virtual machine emigration time by using the Neural network NN and fuzzy logic systems. This kind of systems helps cloud providers to assign resources to the software applications and services automatically. But this model will not add to cloud utilization and quality of service QoS, but it will reduce the response time and costs. Beloglazov et al. in (Beloglazov et al, 2011) proposed an architecture framework and concepts for efficient energy usage in cloud computing. Depending on energy conscious allocation, that saves datacenter resources to user applications development. Also the efficiency of energy consumption for datacenter while meeting the quality of service QoS criteria. We have to consider the load balanced algorithms by using of the fuzzy model in CC. Sethi in (Sethi et al,2012) has proposed a version of algorithm which takes input of data for example the processor speed and carried out the load of virtual machine and the output balanced load. While Zulkar in (Zulkar and Azad, 2013) introduced an algorithm of efficient dynamic fuzzy load balancing, that cloud will predict where the VM will coming task will be scheduled.

2.2.1 Power Energy Consumers

The consumption of energy in datacenters could be specified by the processor, RAM, storage and network mediator. The processor uses the biggest portion of power energy; processor utilization is identically proportional to the whole system burden, according to studied values, maximum power consumed.

2.3 Power Consumption and Software

2.3.1 Fuzzy Based Approaches

The architecture of Fuzzy essentials shown in figure 2.4, used to expose or detect the previous status of virtual machines position, and distribution level in various methods by changing the input variables and control the base as the level demands. The proposed work concerning about applying fuzzy logic for VMs level without applying fuzzy approaches for the current virtual machine optimized level , and applying the same method on new identified fuzzy model for the over-utilized of the host detection.

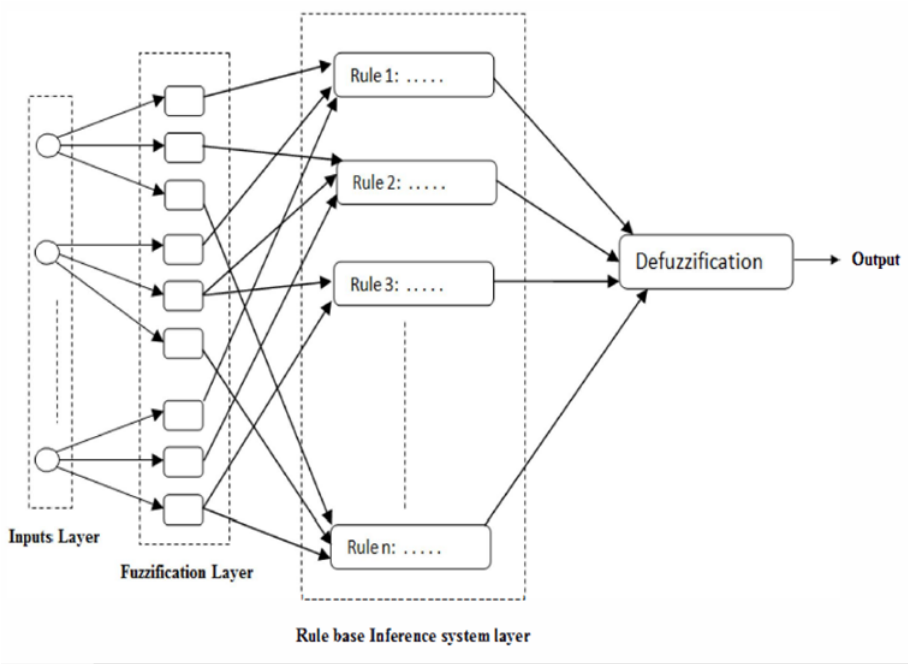

Figure 2.3.1: Shows the architecture of Fuzzy essentials

CHAPTER 3

HARDWARE STRATEGIES AND SOFTWARE TECHNIQUES USED TO REDUCE ENERGY CONSUMPTION IN GCC

According to researches the techniques of reducing power energy are divided into two main parts, the hardware strategies and the software techniques, and the hardware strategies divided into four sections, the Green compilers, Dynamic voltage frequency scaling device, sleep mode and Feedback driven threading. While the software techniques are divided into green compilers, readymade resources, repetition and other techniques explained briefly.

3.1 Hardware Strategies

3.1.1 Power Supply

If a Power supply unit meets the requirements, it will use only the power needed for a given workload. On other hand, it will not use additional power than the demanded. It is the millstone of a green IT, due to it manages the power for all the other components. The efficiency of power supply units could reach 80% as the industry initiative which called 80 PLUS certificates.

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3.1.2 Dynamic Voltage Frequency Scaling (DVFS)

It is a device used to decrease the supplying electrical voltage to CPU in case of low load by reducing processor speed but still performing tasks. That will be enough for the system requirements. Also it will decrease the frequency which will cause to reduce the power consumption.

3.1.3 Sleep Mode

After finishing executing tasks, the consumed energy by the system will be reduced if the CPU put into sleep mode.

3.1.4 Power Management Techniques At Operating Systems Level

There are many power management techniques, which control the amount of parallelism dynamically. FDT which is an abbreviation of Feedback driven threading, is a framework that controls the amount of threads using execution time details. This technique can decrease the execution time and power consumption by 70%.

3.2 Green Software Techniques

During software life cycle development like analysis, design and implementation, the power electrical energy can be saved. In design stage, we can conserve energy by making efficient energy software structure and implementation .Software engineers can use the following techniques.

3.2.1 Using Green Compilers

Many green compilers became available, which they can be implemented in order to save energy. For example (Green Hill Compiler) can be used for high programming languages like (C) and (C++).

3.2.2 Using Readymade Or Ripe Computer Resources

There are many available resources for use as service, like currency converter, calculator, and so forth. Using them in software can be useful for time, cost and energy conserving.

3.2.3 Using Repetition

In case of recursion, energy could be consumed more because of a longer running time took a place. The optimum solution is to avoid recursion in software development.

3.2.4 Other Techniques

Inside addressing memory and instructions registering changing the order of instruction in the position which is suitable for sleep mode, could cause to decrease energy consumption. Also using gray code actually leading to decreases the consumption of electrical power energy by 36% compared to binary exemplification of the memory.

Other methods are energy cost tree optimization and power-energy conscious compiler for power-energy cost database in each transaction. Also Loop optimization is a method used to enhance and improve energy efficiency, this method check the nested loops by dependency graph. In case of no cycle found, the compiler will make a loop for each representation and execute them in parallel.

3.3 Environmentally Friendly Energy Recourses for GCC

There are many ways to get a clean and sustainable electric power energy, which will cause to reduce the carbon dioxide emission and reduce the total cost. And hence we proposed some resources and a brief explanation about each of them.

3.3.1 Improved Geothermal System

The main objective of Enhanced Geothermal Systems is to saddle the heat which naturally emitted by earth to produce electrical power. Enhanced Geothermal System EGS is based on load resources, which let it to produce electrical power energy 24 hours per a day and in the same time it helps in totally reducing of carbon dioxide (CO2) emissions.

3.3.2 Nano-Solar

Solar energy is one of the best renewable resources of power; it is clean, safe and continuous most of the year’s days in Middle East, approximately 360 days per a year. The system used in two ways, on grid and off grid system, the first system collect power electric energy from the PV cells and sends it to user and directs the redundant to the general grid. While the off grid system, collect the power from the cells and direct it to batteries. Another technique is Nano-solar which reduces the production of the electrical power in US from 3$ per watt to 30 cents per watt using a special power sheet cells.

3.3.3 Orbiting Solar Arrays

This technology stills under research. The theory said that the panels should be put outside the earth's atmosphere in orbits around the earth; these panels will reflect the solar power back to a receptor which will convert this beam into usable electricity. And the main advantage of this technology is the huge amount of energy that could be produced.

3.3.4 Smart Buildings

Green buildings are one of the constructions which are environment friendly and low power energy consumer, they represents the best utilization of land, water and energy resources. The designed system simulates the natural systems and conditions.

3.3.5 Smart Grids

The international Energy Agency report states that between 2003 and 2030 about 16 trillion US dollars will be spent overall the world on developing and installing smart grids. The main advantage of smart grid is to treat and solve the chronic problems of the current electrical grids. The distribution of electrical power energy and the consumption of electrical power energy will be more efficient and will as well reduce the costs.

Recently people are, conscious about environment conservation, and they have been directed to use the friendly environment products. And this is will not only help them now but will give a chance to the next generations to live a better life. As seen the green technologies and techniques succeed to support us with following advantages:

- Achieving the sustainability and reliability for users and employees.

- Matching the agreements and regulations requirements.
- Conserving energy and resources so that will save money as well.
- Decreasing the environmental effect of CO2 footprints.
- Optimizing the operation to reach the maximum efficiency.
- Reducing the risks existing now in the desktops and laptops like chemicals which known that cause diseases.

Preserving resources so that lower energy will be used to complete the operation.

CHAPTER 4

ALGORTHIMS USED IN GCC TO REDUCE ENERGY CONSUMPTION

In this chapter we are going to explain some algorithms, which help in reduce electrical power energy by driving the cloud into way which use fewer resources and utilize them efficiently. And that leads to reduce energy consumption and carbon dioxide emission.

4.1 Nuts Algorithm

We chose NUTS algorithm because of its efficiency in secluding tasks as their priority and this leads to utilize the available recourses in the optimum way. (Sanjeevi et , al , 2017).

4.2 Nuts Scheduling Approach

Users of different fields like individuals, firms and organizations operate their services and applications on various VMs, using specific resources, Platforms, and Assure of quality of service QoS of SLA is considered through virtualization. Hence, we present an algorithm called NUTS a Non-Urgent & Urgent Task Scheduling Algorithm that use DVFS Dynamic Voltage & Frequency Scaling. The main purpose of this algorithm is to decrease the consumption of electrical power energy by scheduling the tasks required to be performed in datacenter in more efficient way so the IT devices and tools consume less energy than the normal conditions.

The algorithm proposes a complete model to reduce electrical power energy usage of cloud data center while insuring quality of services QoS for green IT or GCC. The NUTS algorithm deals with urgent and non-urgent tasks that are running or will be in the datacenter to match between decreasing energy consumption and tasks assurance while increasing the sustainability and reliability of cloud datacenter CDC. Dynamic Voltage and Frequency Scaling is used to reduce electrical power consumption of other devices in datacenter DC like cooling, lighting… etc.

Surely by reducing the consumed energy, the CO_2 emissions will be reduced and that will bring the datacenter to green area that respects the users' demands and as well will convert the data centers to environment environment-friendly. And of course will decrease the economic costs that the normal datacenters required to operate and sustain.

4.2.1 The Architecture of NUTS

The system Architecture of NUTS consists of three sections mentioned below:

User section: Consuming energy starts with giving order by user based on type of task and this is the beginning of architecture. The task given by user close mainly to the frequency of load that the task required. Service level Agreement (SLA) should be considered to achieve sustainability of the system.

Recourse section : Based on the load given by user the resource section in datacenter of cloud entered to Virtual Machine and host section and by using the non-urgent and urgent task scheduling algorithm NUTS, virtual machines VMs could be categorized in ascended on contrary of the DC.

Scheduling part: Virtual Machines manager create basic VMs and organize the task on allocated virtual machines according to NUTS algorithm. As well the service of Level Agreement SLA took in consider. After the algorithm makes the decision, the solution is send to virtual machines Manager. The main feature of this architecture that is the NUTS using dynamic voltage and frequency scaling (DVFS) controller which create the difference.

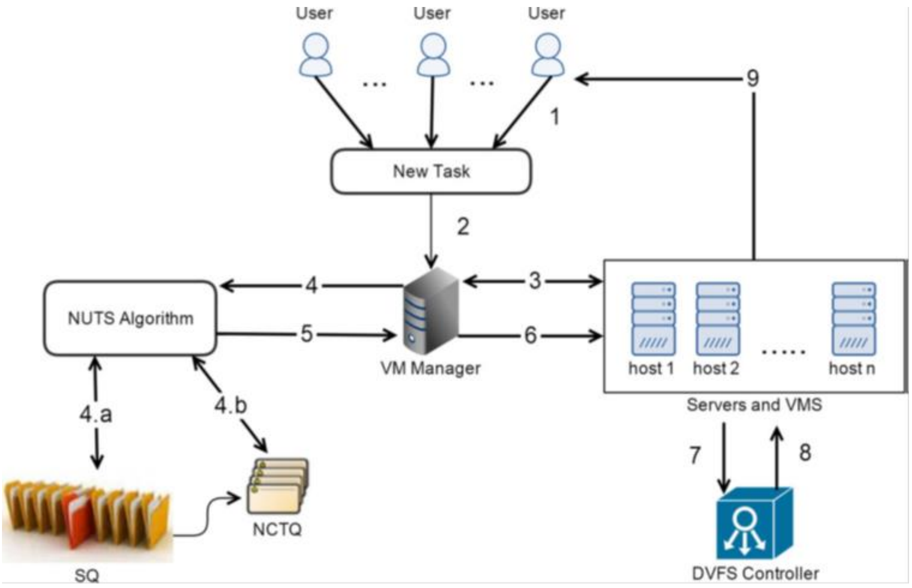

Figure 4.2.1: (NUTS) scheduling architecture

4.2.2 The Non-Unurgent and Urgent Task Scheduling (NUTS) Algorithm

The NUTS algorithm composed of SQ & NCTQ. If we want to describe the SQ job, we can say that the SQ attributes to hold new tasks and the important tasks then waiting for scheduling process. While NTCQ takes the non-completed tasks in SQ, the organizer. The scheduler monitors both of NCTQ and SQ, the scheduler takes the tasks that are exists in NCTQ and send them to VMs. The consumption of electrical energy in hosts in datacenters adopts the CPUs, Storages, and RAMs … etc.

The total consumption of energy of DC is equal to the energy consumed by SQ and the energy consumed by NCTQ. Because NCTQ complete the SQ in most cases like incomplete tasks and delayed tasks, and that shown below in equation 4.1.

$$E_{DC} = E_{SQ} + E_{NCTQ} \quad 4.1$$

When the task obtained, it will be realized to SQ, hence when the urgent tasks occurs they compared with previous tasks existing in queue. While the task is not urgent, but the urgent task take place instead of the non-urgent and if the following task not urgent it will remains in the next position in queue. This classification is made, so the allowed period for the task in case of failure in SQ will be directed to NCTQ. The task execution period is studied from the previous scheduled event. The packing technique function is called to choose a host which containing the largest number of virtual Machines and match them to host. The dynamic voltage and frequency scaling is a mechanism which the voltage and frequency of processor are performed by it. The milestone of approach is to determine the electrical power utilization of hosts for a specific workload which overcoming taking in consider as a watt per second. By using the dynamic voltage and frequency scaling technique, the voltage (volts) and frequency (Hz) are close enough to match the necessity of the physical CPU plan and transforming the working voltage without shutdown the power outfit and turn it on again.

4.3 A Preemptive Priority Based On the Tasks Scheduling Algorithm

In green computing concept we can categorize task secluding as one of milestones; many researches have been done on preemptive priority based on the tasks scheduling to reach the maximum benefit of Green Cloud Computing. The basic concept of the algorithm is prioritizing the taking on every cloud. We focused on energy consumption in datacenter and CO2 emission. The algorithm of green scheduling is effective in energy consumption efficiency based on task priority scheduling.

4.3.1 Criteria Followed

Preemptive priority based on the tasks scheduling algorithm allows each task to be stopped during the execution if another higher priority arrived. Actually it’s a helpful technique. Hence, we presenting a useful efficient tasks scheduling technique in green cloud computing which use preemptive priority based on the tasks scheduling algorithm which focuses on reducing of the cost of the power consumption. The server of computing is selected based on the satisfying the minimum requirements of the task as per the best fit

4.4 Dynamic Adaptive Particle Swarm Optimization Algorithm (DAPSO)

Many of algorithms proposed to solve the task scheduling problem like swarm optimization algorithm PSO, optimization of Ant Colony ACO, Cuckoo search CS, etc. Hence we propose a Dynamic Adaptive Practice Swarm Optimization Algorithm which is a development of basic (PSO) algorithm to improve the runtime by minimizing the make-span of a specific task group, and simultaneously improving the resource utilization. Another algorithm has been presented by merging the Dynamic Adaptive Particle Swarm Optimization with Cuckoo search CS algorithm, and we called it MDAPSO to improve the job scheduling in Cloud computing to reduce the runtime and maximize the resources utilization.

4.4.1 Scheduling Algorithm system

The figure 4.2 which is shown below illustrates a brief view of the scheduling system we are talking about. We have 3 modules, the first one talking about representing the group of cloudlets tasks. The second module is allocating algorithms by mapping them and denoted MA, which expect the time for each task to be allocated on each VM and used to run the cloudlets, also expected time of them. So they have been have been stored in (M x N) matrix, where M refers to the number of VMs and N represents the number of cloudlets. By simple math calculation N over M will be greater than 1, and then the estimated running time (ERT) is the time of performing task j on resource r.

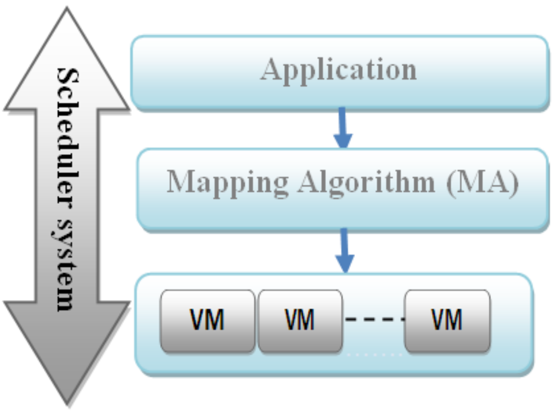

Figure 4.4.1: The scheduling system

Decreasing make span is the main purpose of allocating tasks on VMs where the makespan is known as the completion time of the task.

4.4.2 The (PSO) Algorithm: The Basic

Considering the task scheduling using PSO algorithms which guide us to enter the schedules like the search solution, as well finding the proper maps through problem solutions. Now according to DAPSO algorithm using array of elements each object shows possible solution for the job assigned using an array consist of n elements. Where those elements produce a real integer value between 1 to m, the figure 4.3. Shown below illustrates the process of assigning ten elements of jobs to 5 VMs.

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Particle1	VM1	VM2	VM1	VM2	VM1	VM2	VM3	VM4	VM4	VM5
Particle2	VM2	VM2	VM3	VM2	VM4	VM1	VM1	VM5	VM3	VM5
Particle3	VM3	VM3	VM2	VM3	VM5	VM4	VM1	VM4	VM2	VM4

………. ……….

Figure 4.4.2: Shows objects representation

4.4.3 DAPSO Algorithm

Dynamic adaptive swarm optimization DAPSO has been proposed to solve the basic PSO related problems especially in inertia weight where the great value of inertia weight facilitates the international search but the low value considered about the local search.

The algorithm DAPSO is optimized as the following:

- Randomly initialize the swarm object.
- For each object, evaluate the fitness function.
- Compare the value of each object, before and after the optimization.

- Check if the fitness function value of each object now is better than the previous value after that set this value as the best value of the object.

However, despite the features of our algorithm DAPSO, there is a disadvantage which is when the inertia weight is reduced; it can’t increases to meet the swarm requirements for searching new areas. As well DAPSO cannot recover its exploration mode. To overcome that we can combine the DAPSO with CS algorithm to enhance the ability to search addresses because the CS algorithm has a group of techniques allows the combination to search locally and internationally simultaneously to find the best results. According to the work performed , a dynamic adaptive particle swarm optimization DAPSO has been proposed and implemented to overcome of the basic PSO problems enhancing the local search as well. To estimate the presented MDAPSO task scheduling and allocating algorithm a comparative expanded research has been done over the original PSOCS,DAPSO and PSO algorithms , regards to makespan and resource utilization.in inertia weight , where the high value of inertia weight expedites the international search while the small value of inertia weight expedites the locally search. As well the new job or task secluding algorithm has been proposed to reduce the makespan and increase the utilization of resources in cloud computing. The new algorithm is regarded as the combination of CS and DASPSO algorithms to produce a new algorithm called the MSAPSO. Where the dynamic adaptive particle swarm optimization algorithm is used to optimize the inertia weight and the CS is used in the domestic search. And the performance is increased by adapting the inertia weight and

4.5 EEDD Algorithm

In Cloud computing, the number of communications of the devices, nodes and servers are integrated to distribute the resources based on user demand and servers are available over the internet by on-demand computing. The services offered are the infrastructure, Platforms and software services. And there are three types of clouds: the public clouds, the private clouds and the hybrid clouds deliver the service to the end user.

Cloud networks made challenges with the performance, architecture, reliability maintainability, protection and virtualization. The cloud stakeholders or provider concerns on energy consumption in the datacenter, but they didn’t take in consider transferring data between cloud datacenters and accompanied energy consumption and costs. The cloud networks spend additional bandwidth for the small applications while delivering the user requests simultaneously the network requires more bandwidth for user demands.

4.5.1 Network Virtualization

The virtualization of network manages the network resources and the simulation ability of hardware infrastructure. It builds the logical view of both hardware and software. The virtual network offers clever abstract which is easy and smooth to install and changes the network resources. The network virtualization covers the complicated requirements in multiple tenancy environments and can deliver separate network virtualization from other networks in environment.

4.5.2 The Method of Network Energy Utilization

The infrastructure of virtualize network is being built with various layers of hardware resources, which includes gateways, switches, hubs, modems, etc. The consumption of energy resources comes from the virtualization network infrastructure.

4.5.3 Decreasing Network Energy Method

The decreasing of energy of network can be computed by knowing the components utilization duration, and what is the interval needed to transfer the data and what is the rate of transferring and how many network resources can be utilize . By on-demand requites the allocation of bandwidth and the numbers of components of network are decreased using efficient energy delivery algorithm in the cloud network.

4.5.4 Algorithm of Efficient Energy Utilization of Data Delivery

Energy consumption is the main problem in Cloud Computing Network Communications. The algorithm of efficient energy utilization of data delivery used to extend the bandwidth consumption and decrease the utilization of network components in Green Cloud computing. The main aim of GCCN taking consider of the high data rate or bandwidth for cloud applications and keep watch of the network components for the purposes of energy saving and environment conservation .The following procedure demonstrates the algorithm working way:

- Identifying resources and available resources.
- In the way for categorize sources and destination.
- Knowing the arrival job size before classifying the direct path.
- Categorizing the specific resources for coming task with operating time.
- Allocating the task to the certain resource using fitness function {Bandwidth}> $\sum Bandwidth$ which is the importance of the solitary tasks.
- Resources relocation depends on the direction of the job processing time.
- For additional deployment, turn off the unutilized resources and repeat the steps from 1 to 7.

4.5.5 The Consumed Power Energy

The power energy is increased for the cloud computing network components with network traffic. Figure 4.4 below explains the details required by categories of resources as a performance index of overall capability. The electric power goes to steady state for the huge broadcast rates where (85 to 97%) of energy consumed by chassis while line cards are totally a little amount which is approximately about (3 to 15%) of the total energy consumed in cloud network. Depending on utilization of resources, the given income from network traffic, router, switch, constrained and linked components by QoS. The elements which are the port transceivers are reducing energy. As shown in figures 4.5 and 4.6. Transferring data to cloud network taking more time while a number of resources must be in switched on statues, concluding that the consumed power energy will be increased, but after applying the Algorithm of efficient energy utilization of data delivery, the unutilized resources and idle network sources stay in turned off status. In case of increases of users' demands, the cloud network resources will be in switched on status. By this process the energy consumed by cloud network and the utilized resources will be decreased. As shown in Figure 4.4.

Network resources name	Energy (in terms of power consumption approximately)
Router	20 W (Karuppasamy and Balakannan 2018)
Switch	15.4 W (Karuppasamy and Balakannan 2018)
Cabling	0.4 W (1 Gbps) 6 W (10 Gbps) (Kliazovich et al. 2010)
Linecard	5 W (Guo et al. 2009)

Figure 4.5.1: Shows network energy consumption

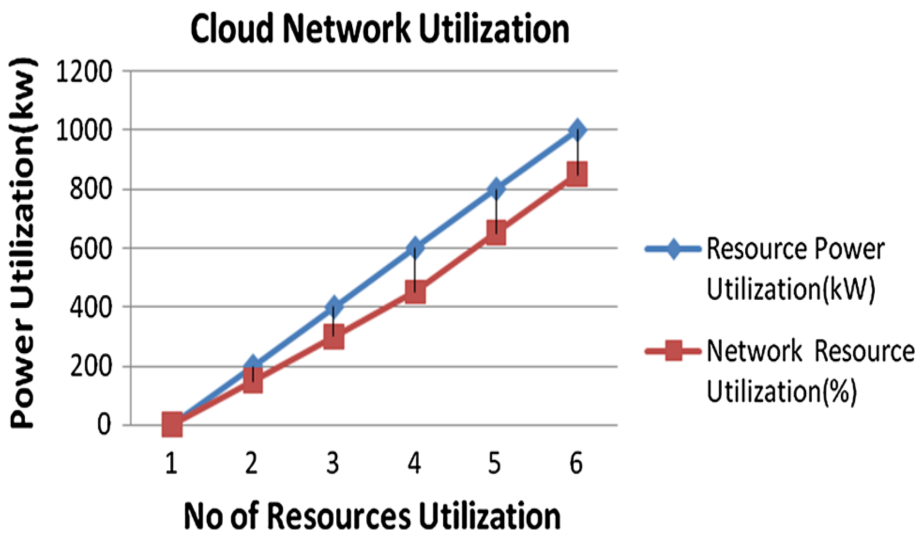

Figure 4.5.2: Shows cloud network power and utilization

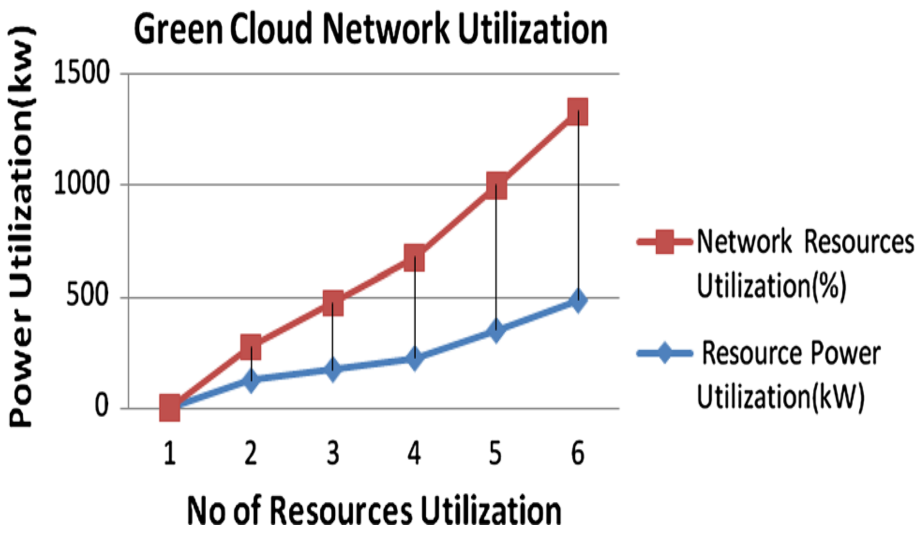

Figure 4.5.3: Shows cloud network power utilization and number of resources utilization

Network resources	Power usage (kw-365 days)	Carbon footage (Kgs-365 days)
Router	175.2	0.408
Switch	134.904	0.314
Cabling	3.504	0.008
Linecard	43.8	0.102

Figure 4.5.4: Shows the Power usage in kWh and the carbon footprint in Kgs

The proposed algorithm developed an approach for enlarge the performance of the network utilization of resources in cloud computing and minimizing the dynamic CCN components and as a result the reduction in electrical power consumption. The challenge was to decrease the energy consumption without affecting the performance of network transferring system.

4.6 VM Load Balancing Algorithms

Hence, we are going to propose some algorithms and test them in our proposed software CloudAnalyst and see the impact of them on the time of response and on the cost. The VM load balancing algorithms are used in datacenter to balance the requests between the available VMs.

4.6.1 Round Robin Load Balancer

Round-robin is one of the algorithms employed by process and network schedulers in cloud computing to allocate VMs to the proper physical machine, and generally using time-sharing giving a job a time slot, if the task not completed, it will be resumed next time a slot assigned to the that process If the process terminates or changes its state to waiting during its attributed time quantum, the scheduler selects the first process in the ready queue to execute.

4.6.2 Throttled Load Balancer

The throttled load balancer keeps an index table of virtual machines and their states, if they are available or not and at the beginning all the states of VMs are being available. Then the Data Center Controller starts to receive requests, after that quire the Throttled VM Load Balancer for the coming allocation and the Throttled VM Load Balancer starts to parses the allocation. Then starts to descending them until find the available virtual machine or the schedule found parsed complete. We have two cases, the first if found, and then the Throttled VM Load Balancer returns back the virtual machine to the Data Center Controller. Then the Data Center Controller sends the demand to the virtual machine which known by the ID, after that the Data Center Controller sends a notification to Throttled VM Load Balancer for the new available allocation .Then the Throttled VM Load Balancer updates the allocation registry. The second case if not found, then the Throttled VM Load Balancer returns to step one, later the Data Center Controller reserves the demand , when the virtual machine completes the processing request and the Data Center Controller receives the cloudlet response , then it sends notification to the throttled VM Load Balancer of the Virtual machine new allocation . After that the Data Center Controller checks for new requests waiting in the queue. If that happened the Data Center Controller sends the demand to the virtual machine which known by the ID again. Then the Throttled VM Load Balancer returns back the Virtual machine to the Data Center Controller.

4.6.3 Active Monitoring Load Balancer

The main job of load balancer is to maintain the workloads equal overall virtual machines. And hence, the algorithm used is quite similar to the throttled algorithm. Firstly the Active VM Load Balancer maintains an index schedule of virtual machines. When required to allocate a new virtual machine from the Data Center Controller, it parses the schedule. The Active VM Load Balancer returns the virtual machine ID to the Data Center Controller and the Data Center Controller sends the demand to the virtual machine known by that identification .The Data Center Controller sends notification to the Active VM Load Balancer of new allocation. And the Active VM

Load Balancer updates the allocation schedule by adding the allocations count for the mentioned virtual machine. So when the virtual machine completes processing the demand and the Data Center Controller receives the response from cloudlet, it sends notification to the Active VM Load Balancer of the virtual machine new allocation. Then The Active VM Load Balancer registers the allocation to the table by reducing the allocation.

4.6.4 Service Broker Algorithms

4.6.4.1 The Closest Data Center

The closest data center of Service Broker which keeps the index schedule of all Data Centers classified by their region. When the user in base sends a message he queries the closest data center of Service Broker for the destination of Data Center Controller. The closest data center of Service Broker call the region of the sender of the demand and queries for the region a proximity table for that area from the internet characteristics. The closest data center of Service Broker catches the first data center mapped at the closest region in the proximity schedule.

4.6.4.2 Performance Optimized Routing

This algorithm is used by the best response time service broker, the best response time service Broker keeps the index of DCs available. When the user in a base sends a message he queries the closest data center of Service Broker for the destination of Data Center Controller. For the best response time, Service Broker defines the closest DC by using the proximity service broker algorithm. After that for the best response time, service broker repeats the schedule of all DCs and assesses the current responding time in each DC by querying the last registered processing time from internet characteristics. So if the mentioned time registered before the identified threshold, the processing time for this DC is put to zero. Which means the DC was idle for the period which is the minimum of threshold time. If the least assessed response time is for the closest DC, the best response time service broker chooses the closest

DC. Otherwise the best response time service Broker chooses either the closest DC or the DC with the minimum responding time with a 50% chance.

4.6.4.3 Dynamic Service Broker

The Dynamic Service Broker is a development of the two mentioned algorithms before. The closest data center and the performance optimized routing. The dynamic service broker keeps a schedule of DCs and another schedule for the best responding time registered for each DC. When the user in base sends a message he queries the closest data center of Service Broker for the destination of Data Center Controller, the dynamic service broker uses the Service Proximity and the dynamic service broker puts the best responding time registered if the current responding time is better than before.

CHAPTER 5

SIMULATION AND RESULTS OF RESOURSES AND ALGORTHIMS FOR GREEN COULD COMPUTING (GCC)

5.1 Background of Simulation for GCC

The cloud computing in general is a fast world wide spread concept in both field of research and industry nowadays. With the development of cloud computing and GCC, new challenges appeared like how cloud applications are constructed over internet and the challenges of offering cloud computing services over a large scale and cheaper cost. But when trying to apply the services and deliver them to end user , a several factors play role in deployment of services, which are lead us to study many factors like distribution of user bases on land , the availability of internet infrastructure , the dynamic usage and demands of users. To be fair the study of all these factors on actual world is quite difficult, thus the concept of simulation comes up to solve this problem.

Many studies of using simulations over large scales have been made over distributed systems like the CloudSim software and GridSim software at the laboratories of the University of Melbourne. In this work, we use the simulation tool, called (CloudAnalyst) in order to simulate efficiency of different GCC approaches. Then explain (CloudAnalyst) as a project of University of Melbourne which investigates the behavior of large scaled internet applications in cloud environment.

5.2 Simulation Setup for GCC

Firstly, we explain the setup for experiments. In the simulations, CloudAnalyst is used; we used the Throttled Load Balancer algorithm which illustrates practically the using of software CloudAnalyst.

5.3 A Brief Explanation of Using The Simulation Software CloudAnalyst

As can be seen in Figure 5.1, the datacenter tab let us to define the configuration of the datacenter, we can add and remove datacenters of CloudAnalyst and manipulate the following parameters:

- Architecture
- Name
- Number of servers
- Operating System
- Storage cost per GB
- Data Transfer cost per GB (both in and out)
- Region
- Cost per 1Mb Memory Hour
- Cost per VM Hour
- Virtual Machine Monitor VMM

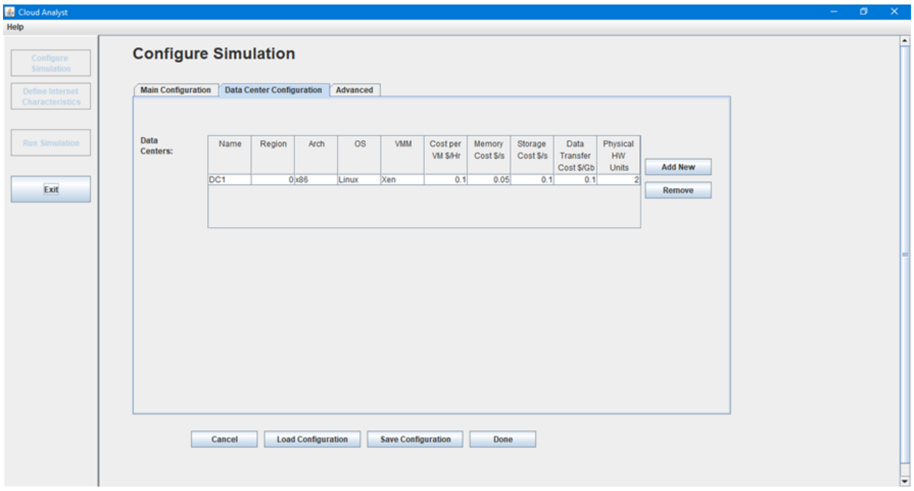

Figure 5.3.1: Illustrates the parameters of datacenter used in simulation in CloudAnalyst

In this screen we can add datacenters and specify their region and their architecture if they are 32-bit or 64- bit and the operating system that will be use and the cost per virtual machine per hour and the cost per single Mb memory per hour also the cost of storage per Gb, and the network transferring cost as well as number of servers. For Addition, datacenter configuration can be made to the following parameters:

- VM allocation policy (time shared/space shared)
- Machine ID
- Processor speed (MIPS)
- Number of processors
- Storage
- Available network bandwidth
- Memory

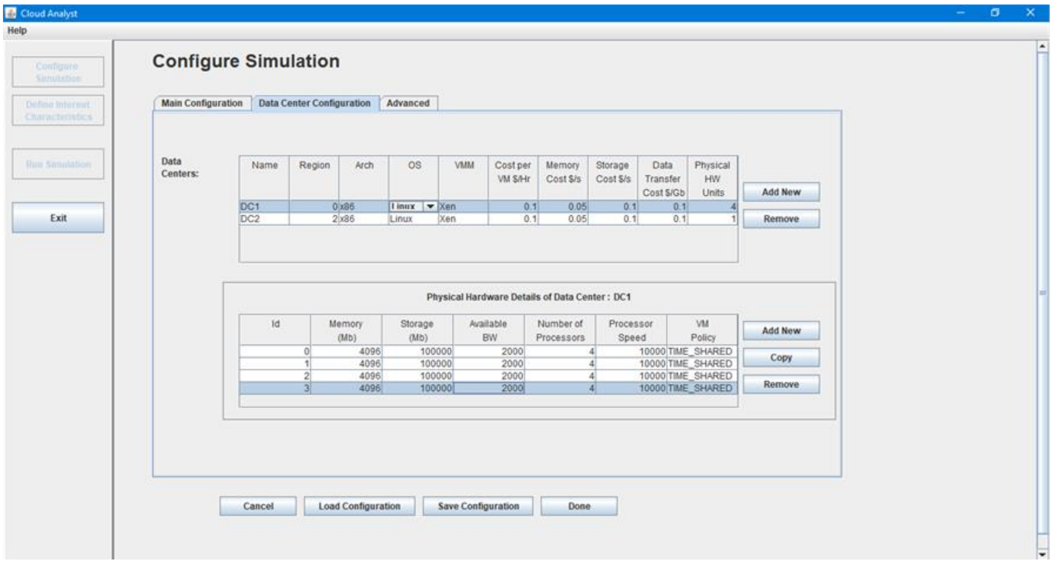

Figure 5.3.2: Illustrates the physical Hardware parameters of datacenter used in simulation

Now, we are going to illustrate important parameters found in advanced tab. Firstly the user Grouping Factor, which shows us the number of users who can be handled in the single pack for the traffic. Secondly the Request Group Factor in DCs which shows us how many requests should be handled in the single unit. Thirdly the Executable instruction length (in bytes) which shows us the effect of this parameter on the length of request. Finally the Load balancing policies available are:

- Round-robin load balancing policy.
- Equally deploy the workloads load balancing policy.
- Throttled load balancing policy.

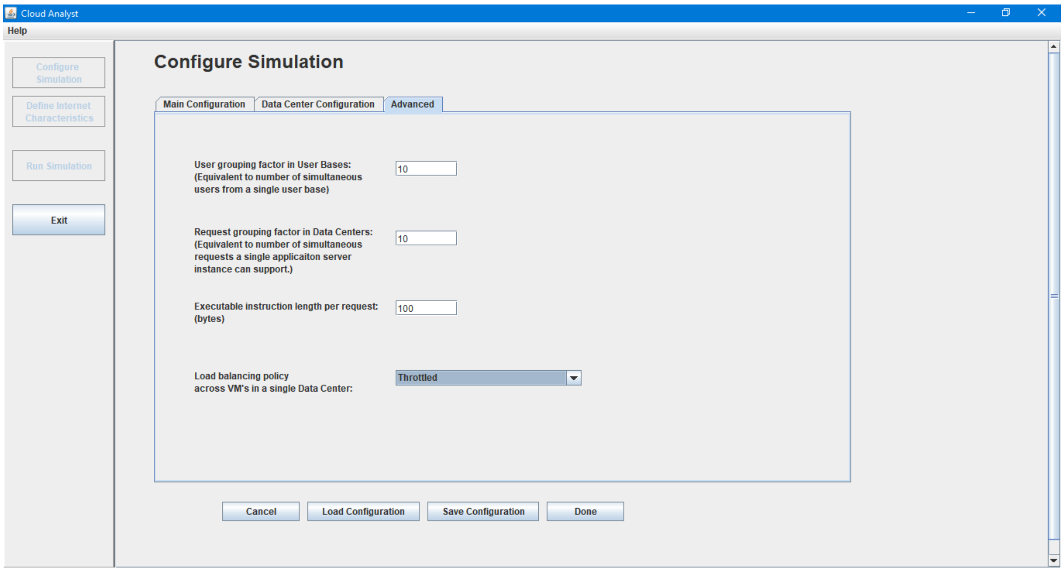

Figure 5.3.3: Illustrates the configuration of advanced tab

Her we used throttled Load balancing policy to ensure the pre-defined number of cloudlets is allocated to a single VM at any given time. If more request groups are present than the number of available VM's at a data center, some of the requests will have to be queued until the next VM becomes available.

Internet Analyzing

The Internet analyzing window could be utilized to put the delay of internet and BW parameters. It shows 2 matrices as shown in figure below.

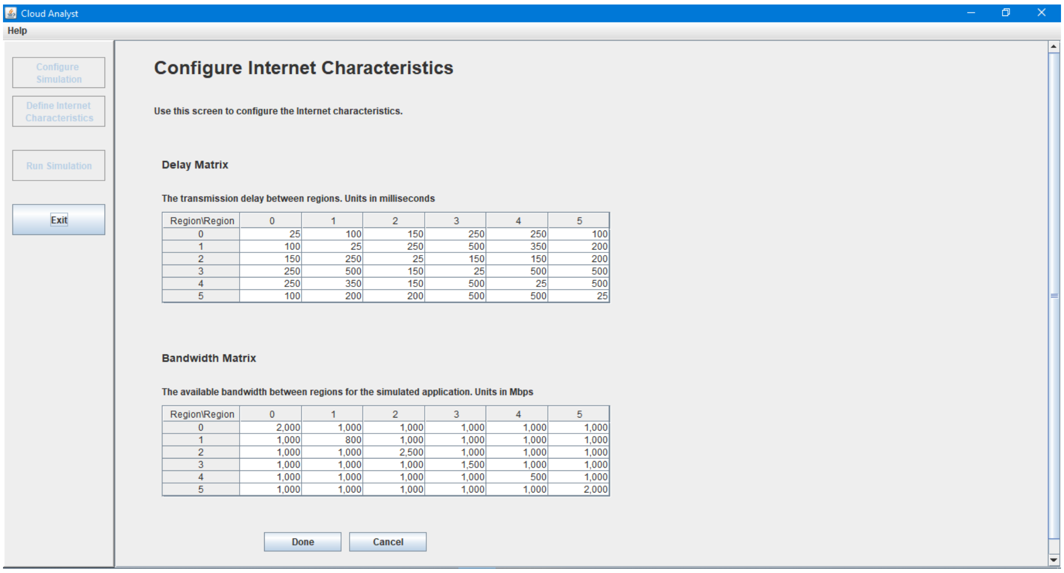

Figure 5.3.4: Illustrates the main configuration simulation screen and Service Broker Policy

The Service Broker Policy

This drop menu appears in the main tab and allows us to select the policy medium between DCs which decides which DC should accept the traffic from user base and the available policies are:

- Closest DC, the DC with the least network delays regardless the network BW from a specific user base and will send the whole requests from that base.

- Optimize response time, while this policy tries to balance between DCs when one DC being overload.

5.3.1 Calculation of CO2 Emission

The overall response time during sending the request by user and receiving the response, affects the CO_2 emission. Because during the response time, the VMs, PMs and cooling system, lighting system and other equipment exist in DC will be used. So when the response time reduce, the CO_2 emission will be reduced because all of these devices will use less power energy and in sequence less carbon dioxide emission.

5.4 A Scenario of a Shopping Website Called "Tabrbour Shopping Center" Simulation

In this scenario we supposed a shopping website which is hosted in seven Datacenters in different regions having five VMs each, and an image size of each VM about 10000 Mb, and here the image size means a copy of the VM, which may contain an OS, data files, and applications. Also the 512 Mb memory and 1000 Mbit/s BW, with seven users. Each user has 10 requests per hour, with a simulation period of 365 days. And we are going to use nine different cases to carry out the results of simulation. And compare the nine cases with the nine different algorithms to find out the optimum way to enhance the GCC concept and reduce the electrical power energy consumption and CO2 emissions.

5.4.1 The First Case Using the Round Robin Load Balancing Policy And Closest (DC) Service Broker Policy.

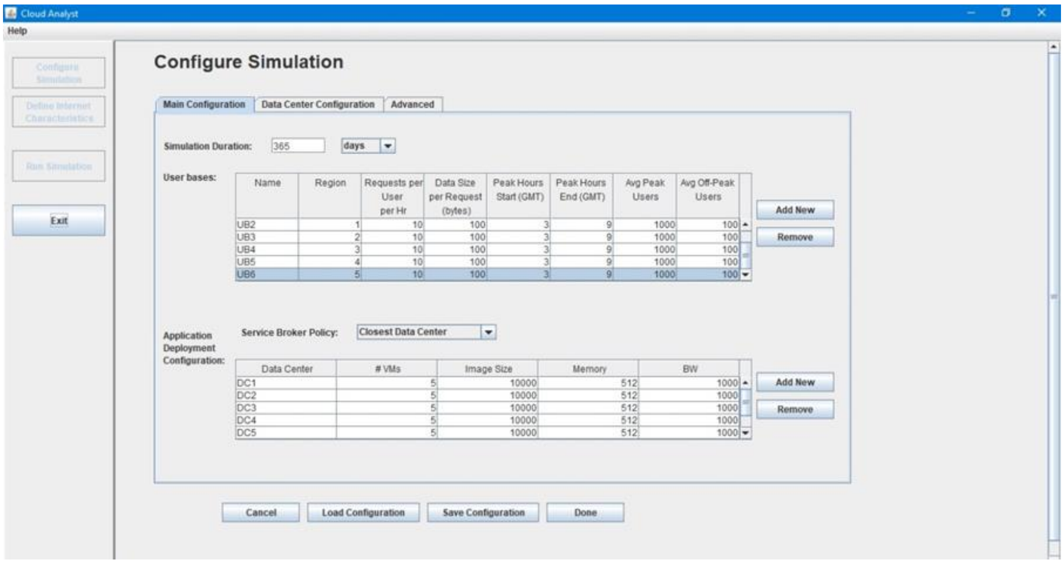

Figure 5.4.1: Illustrates the main configuration screen using the closest (DC) policy

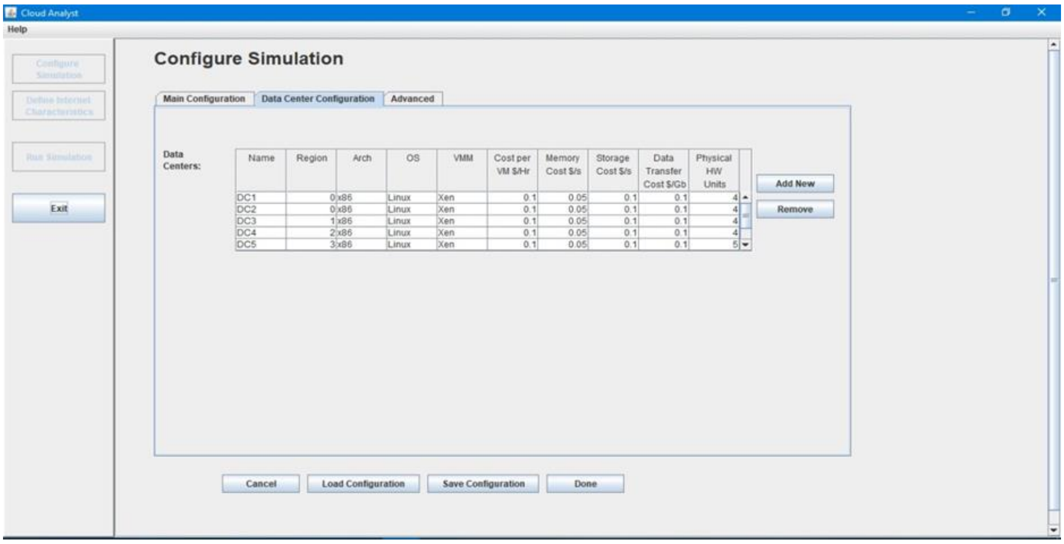

Figure 5.4.2: Illustrates the configuration simulation screen of datacenters

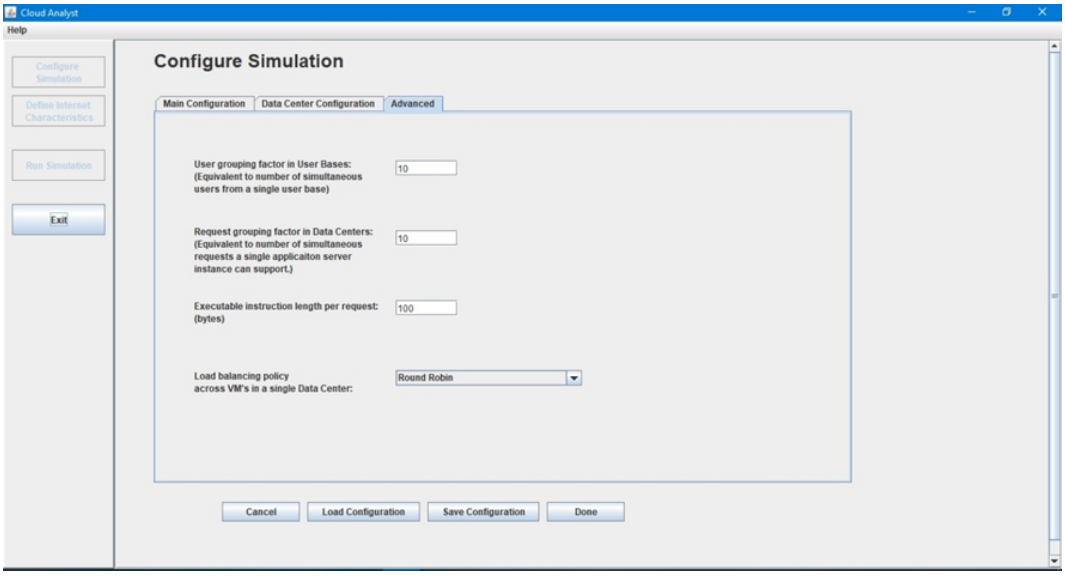

Figure 5.4.3: Illustrates the advanced tab screen with Round Robin load balancing policy

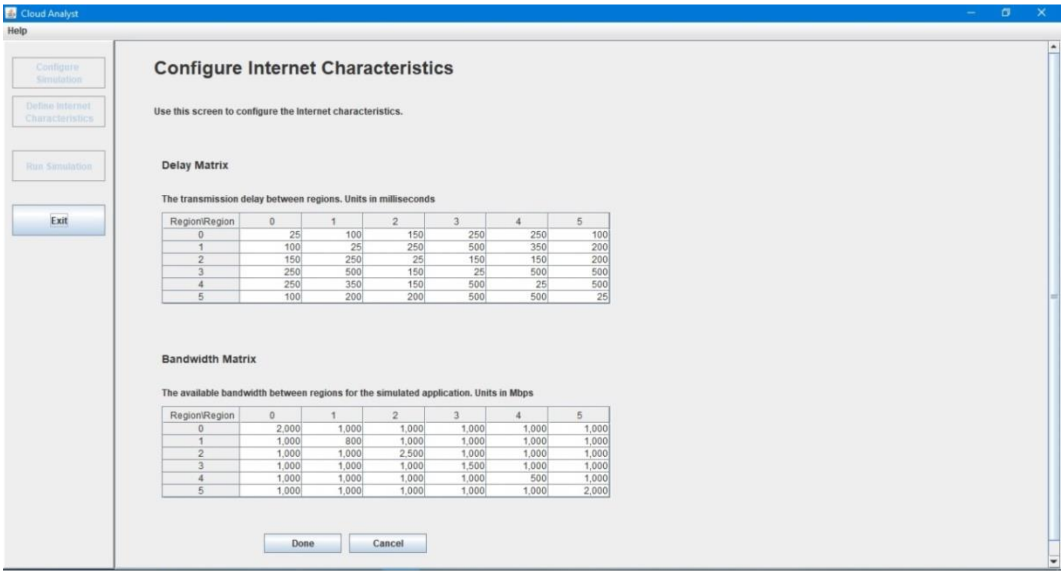

Figure 5.4.4: Illustrates the internet configuration characteristics screen

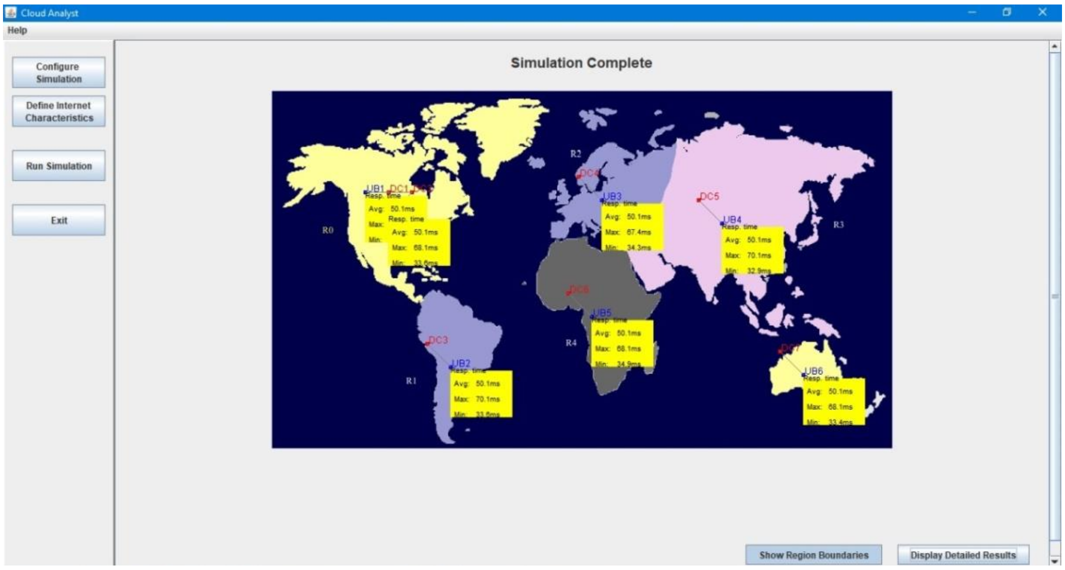

Figure 5.4.5: Illustrates the simulation screen after finished simulation

After the completion of the simulation we have the main response time of the VMs, DCs and network transferring, and hence the response time mean the time of operation of the overall operation which mean the consumption of electrical power energy and the emission of CO2, since reducing this time, proportionally will reduce the power and emission of CO2 to achieve the goal of GCC.

5.4.1.4 The Results of First Case

So overall, the response time in average about 51 milliseconds but during the year there are several periods of time, so the response time expected to rise. Also another important factor to the application owner is how much this operation costs. The table aforementioned shows the overall cost and costs in details. As well we used the Round Robin load balancing policy and closest DC service Broker policy.

5.4.2 Case Two Using the Round Robin Load Balancing Policy and Optimize Response Time Service Broker Policy

In the second case we applied the same steps on same parameters but we changed the services broker policy to optimize response time, while remain the load balancing policy fixed as Round Robin.

5.4.2.5 The Results of the Second Case

As overall, the response time in average about 50 milliseconds but during the year there are several periods of time, so the response time expected to rise. Also another important factor to the application owner is how much this operation costs. The table aforementioned shows the overall cost and costs in details. As well we used the Round Robin load balancing policy and optimize response time service Broker policy and the total cost around the 31 thousand American dollars.

5.4.3 Case Two Using the Round Robin Load Balancing Policy And Reconfiguration Dynamically Service Broker Policy

In the second case we applied the same steps on same parameters but we changed the services broker policy to Reconfiguration dynamically, while remain the load balancing policy fixed as Round Robin.

5.4.3.6 The Results of The Third Case

As overall, the response time in average about 55 milliseconds but during the year there are several periods of time, so the response time expected to rise. Also another important factor to the application owner is how much this operation costs. The table aforementioned shows the overall cost and costs in details. As well we used the Round Robin load balancing policy and Reconfiguration dynamically service Broker policy and the total cost around the half million American dollars, as we notice it’s a huge number compared with the policy used before.

5.4.4 Case Four Using The Equally Spread Current Execution Location Load Balancing Policy And Closest DC Service Broker Policy

In the second case we applied the same steps on same parameters but we changed the services broker policy to closest datacenter, and the load balancing policy as equally spread current execution location load balancing policy.

5.4.4.7 The Results Of Fourth Case

As overall, the response time in average about 50 milliseconds but during the year there are several periods of time, so the response time expected to rise. Also another important factor to the application owner is how much this operation costs. The table aforementioned shows the overall cost and costs in details. As well we used the equally spread current execution location load balancing policy and closest DC service Broker policy and the total cost around the 31 thousand American dollars.

5.4.5 Case Four Using The Equally Spread Current Execution Location Load Balancing Policy And Optimize Response Time Service Broker Policy

In the fifth case we applied the same steps on same parameters but we changed the services broker policy to optimize Response time service Broker policy, while remain the load balancing policy fixed as equally spread current execution location load balancing policy.

5.4.5.8 The Results of Fifth Case

As overall, the response time in average about 50 milliseconds but during the year there are several periods of time, so the response time expected to rise. Also another important factor to the application owner is how much this operation costs. The table aforementioned shows the overall cost and costs in details. As well we used the equally spread current execution location load balancing policy and optimize Response time service Broker policy and the total cost around the 31 thousand American dollars. As we notice it’s a reasonable result for the response time and overall cost and that's comes from choosing the optimize response time server broker policy.

5.4.6 Case Six Using The Equally Spread Current Execution Location Load Balancing Policy And Reconfigure Dynamically Service Broker Policy

In the sixth case we applied the same steps on same parameters but we changed the services broker policy to reconfigure dynamically service Broker policy, while remain the load balancing policy fixed as equally spread current execution location load balancing policy.

5.4.6.9 The Results of The Sixth Case

As overall, the response time in average about 51 milliseconds but during the year there are several periods of time, so the response time expected to rise. Also another important factor to the application owner is how much this operation costs. The table aforementioned shows the overall cost and costs in details. As well we used the equally spread current execution location load balancing policy and reconfigure dynamically service Broker policy and the total cost around the half million American dollars, as we notice it's a huge number compared with the policy used before. As well this results as we noticed came from using the reconfigure dynamically service Broker policy. Hence we can't say that this policy is not useful in general but depending on DC and User Bases locations it's not suitable in our case.

5.4.7 Case seven Using The Throttled Load Balancing Policy And Closest DC Service Broker Policy.

In the seventh case we applied the same steps on same parameters but we changed the services broker policy to closest datacenter service Broker policy, and the load balancing policy Throttled load balancing policy.

5.4.7.10 The Results Of The Seventh Case

As overall, the response time in average about 50 milliseconds but during the year there are several periods of time, so the response time expected to rise. Also another important factor to the application owner is how much this operation costs. The table aforementioned shows the overall cost and costs in details. As well we used the Throttled load balancing policy and closest DC service Broker policy and the total cost around the 31 thousand American dollars. As we notice it’s a reasonable result for the response time and overall cost and that’s comes from choosing the Closest DC broker policy. As we notice, using the closest DC service Broker policy is very helpful in this case due to the short time response which belongs to the short distance between DC and user base.

5.4.8 Case Eight Using The Throttled Load Balancing Policy And Optimize Response Time Service Broker Policy.

In the eighth case we applied the same steps on same parameters but we changed the services broker policy to optimize Response time service Broker policy, while maintains the load balancing policy Throttled load balancing policy.

5.4.8.11 The Results Of The Eighth Case

As overall, the response time in average about 50 milliseconds but during the year there are several periods of time, so the response time expected to rise. Also another important factor to the application owner is how much this operation costs. The table aforementioned shows the overall cost and costs in details. As well we used the Throttled load balancing policy and optimize Response time service Broker policy and the total cost around the 31 thousand American dollars. As we notice it’s a reasonable result for the response time and overall cost and that’s comes from choosing the optimize response time server broker policy.

5.4.9 Case Nine Using The Throttled Load Balancing Policy And Optimize Reconfigure Dynamically Broker Policy

In the ninth case we applied the same steps on same parameters but we changed the services broker policy to reconfigure dynamically Broker policy, while maintains the load balancing policy Throttled load balancing policy.

5.4.9.12 The Results of The Ninth Case

As overall, the response time in average about 51 milliseconds but during the year there are several periods of time, so the response time expected to rise. Also another important factor to the application owner is how much this operation costs. The table aforementioned shows the overall cost and costs in details. As well we used the Throttled load balancing policy and optimize reconfigure dynamically Broker policy and the total cost around the 54 million American dollars, as we notice it's a huge number compared with the policy used before. As well this results as we noticed came from using the reconfigure dynamically service Broker policy. Hence we can't say that this policy is not useful in general but depending on DC and User Bases locations it's not suitable in our case. As well the main reason of the huge cost in this method is that the VMs are fully loaded all the time as shown in the figure below.

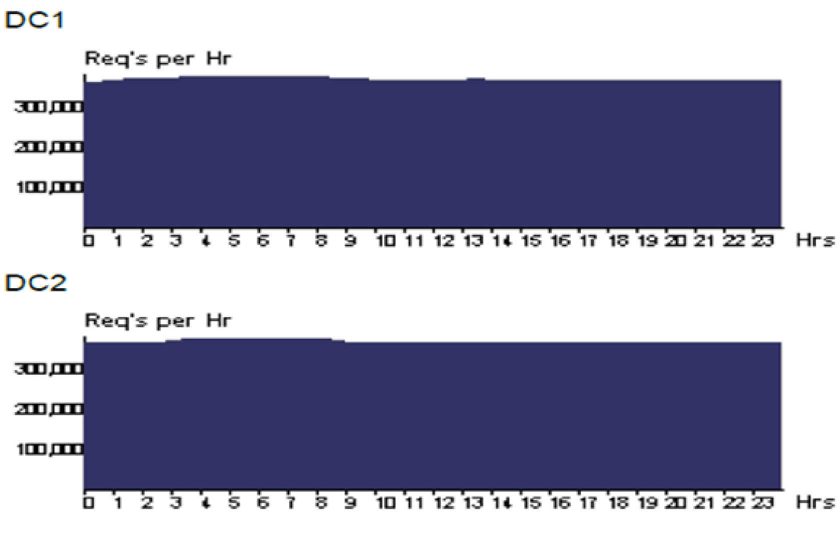

Figure 5.4.6: Illustrates the DC hourly loading

Table 1: Illustrates the comparison between the nine cases mentioned above

Case	Overall response time	Data Center processing time	Total Virtual Machine Cost ($)	Total Data Transfer Cost ($)	Grand Total: ($)
Case 1	50.11	0.48	30660.04	649.89	31309.93
Case 2	50.11	0.48	30660.04	649.89	31309.93
Case 3	55.44	5.81	537801.16	649.89	538451.05
Case 4	50.11	0.48	30660.04	649.89	31309.93
Case 5	50.11	0.48	30660.04	649.89	31309.93
Case 6	50.79	1.15	537803.62	649.89	538453.51
Case 7	50.11	0.48	30660.04	649.89	31309.93
Case 8	50.11	0.48	30660.04	649.89	31309.93
Case 9	50.79	1.15	537798.81	649.89	538448.70

We noticed here that the using of same server broker policy, gives the same average response time and the same costs, regardless changing the load balance policy and this is because of using a small amount of virtual machines, since changing the load balance policy, affecting mainly on the virtual machines, but in this scenario we used only five virtual machines and this is a small number compared with the actual usage in cloud computing.

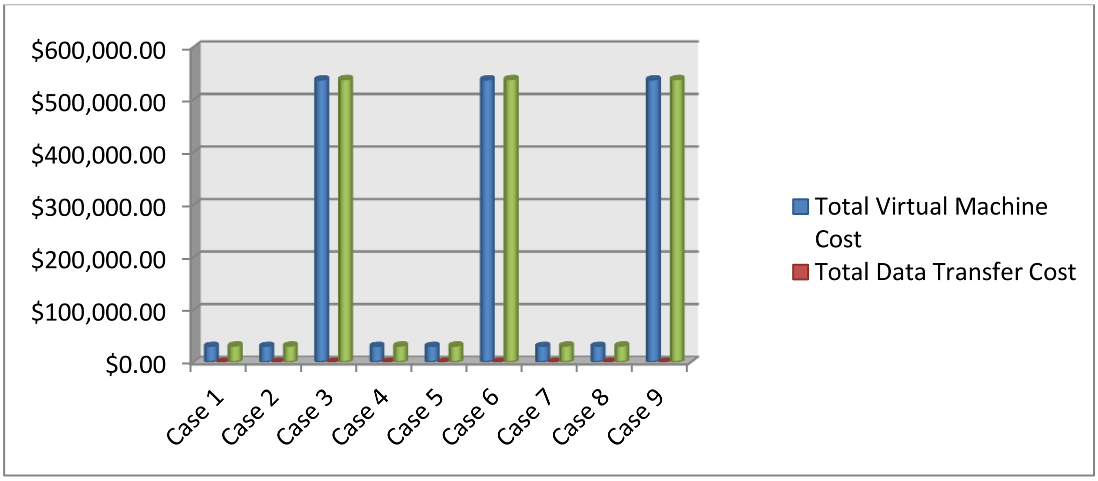

Figure 5.4.7: Illustrates the comparison between different cases respect to cost

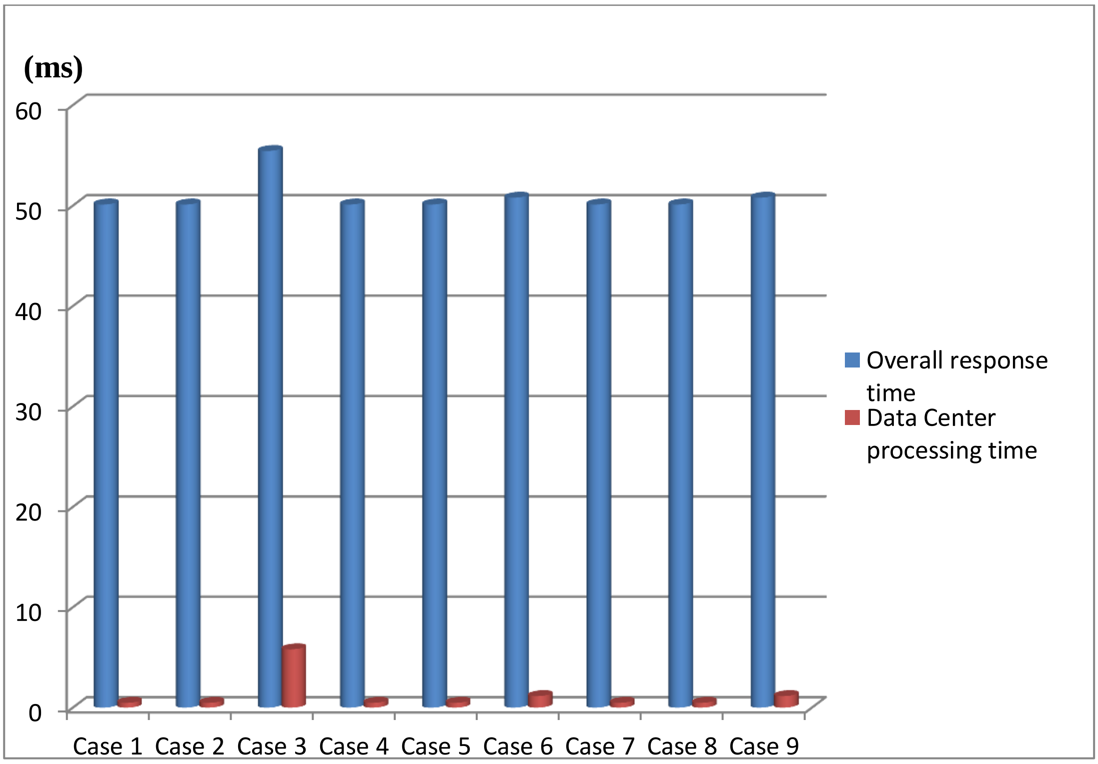

Figure 5.4.8: Illustrates the comparison between different cases respect to time in milliseconds

As we notice bringing the DC closer to users enhance the QoS and response time. And the QoS can be improved also by the application of load balancing at the application stage through DCs by changing the service medium policies. And also at VM stage within DCs. But also the improvements could be performed by implemented the various load balancing algorithms. As we noticed of fully loaded DC while using the Dynamic reconfigurations, a higher storage capacity and higher memory needed to be employed to avoid the overload status. On other hand we recommend using the optimized time response policy since its results are very close to closest DC and also could allocate a user to a nearby datacenter even if t the closest datacenter is not available due to full load.

CHAPTER 6

CONCLUSION AND FUTURE WORK

In this thesis we proposed the concept of cloud computing and how it became a millstone. One of the biggest services provided by giants like Google , Microsoft , IBM and Amazon , and how important is this concept benefited our world since it does not require huge user equipment since a normal device and internet connection will allow the user to use cloud computing . As well as the provided services allows the companies and developers to benefit from the infrastructure and platform, since all these services are available to public and private users. The huge datacenters and network transferring stand beyond the cloud computing , and which consume 1.5% of the US electricity and emitted around 2 % of world CO_2 , hence the green cloud computing has appeared and developed to reduce electrical power energy and the world wide carbon dioxide emission and maintain the sustainability , reliability and efficiency of this service up to date. We reviewed a hardware techniques like green compilers, sleep mode and DVFS , and software techniques like using some algorithms in order to reduce the usage of power electrical energy , and tested some of them using the simulation software 'CloudAnalyst' with simulation of the response time of requests and the overall cost of operating the datacenters. We compared different policies and algorithms for the best choice of GCC. Results show that policies provide less energy consumption and more environments friendly.

The work intended to be expanded in the future and a large number of users in different regions will be simulated, Also a large number of given tasks will be applied to the available algorithms on the project and compare the results to investigate the effect of workload and how it may affect the currently used algorithms. Also a larger number of VMs will be utilized in the future simulation.

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APPENDICES

APPENDIX I

The First Case Using The Round Robin Load Balancing Policy And Closest (DC) Service Broker Policy.

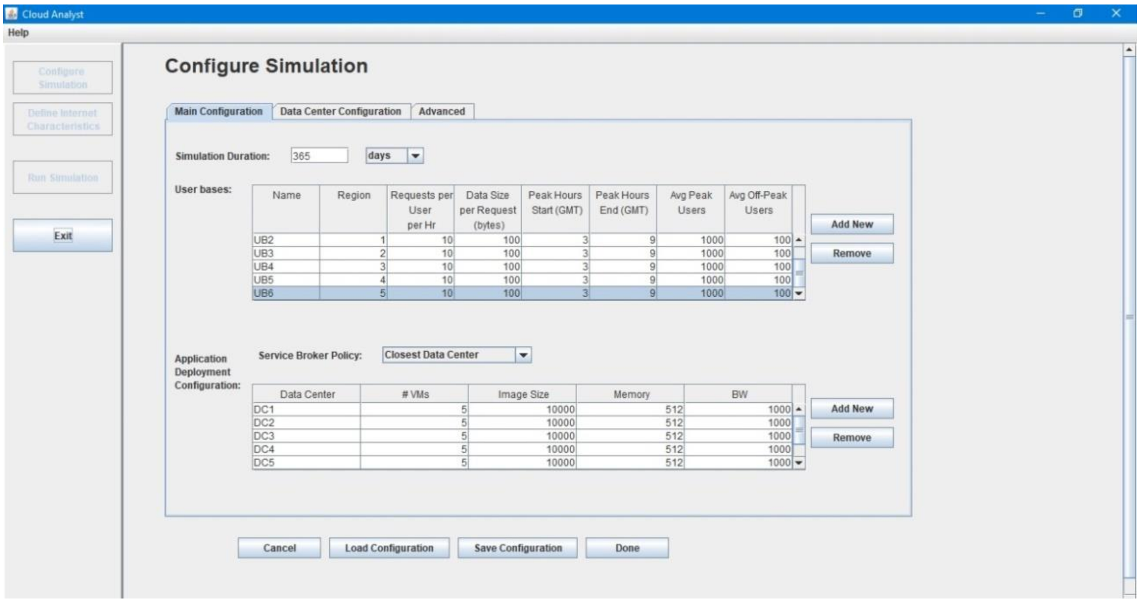


Figure I.1: Illustrates the main configuration screen using the closest (DC) policy

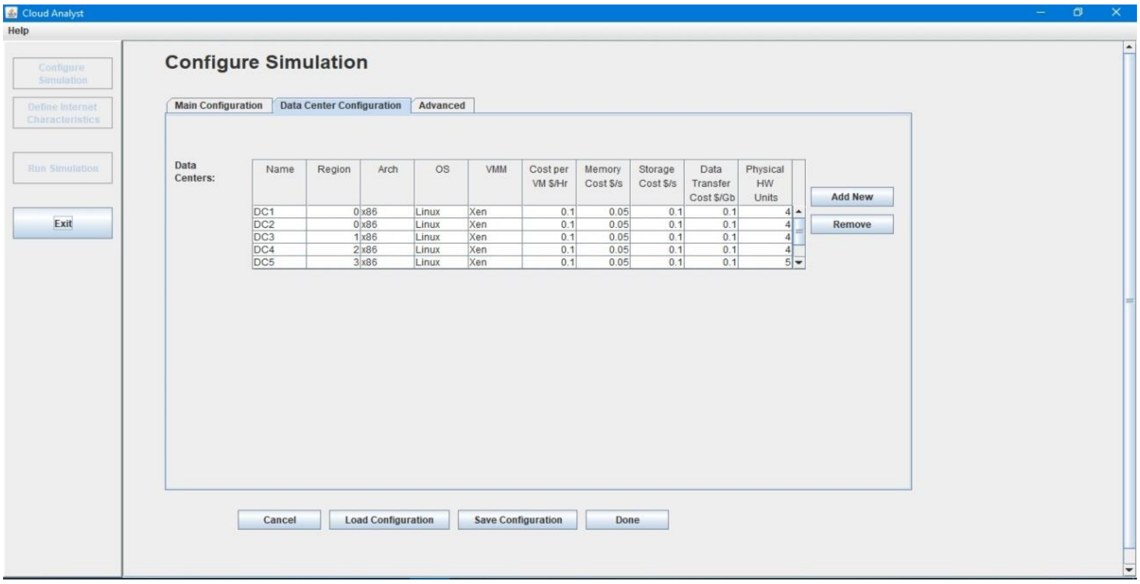


Figure I.2: Illustrates the configuration simulation screen of datacenters

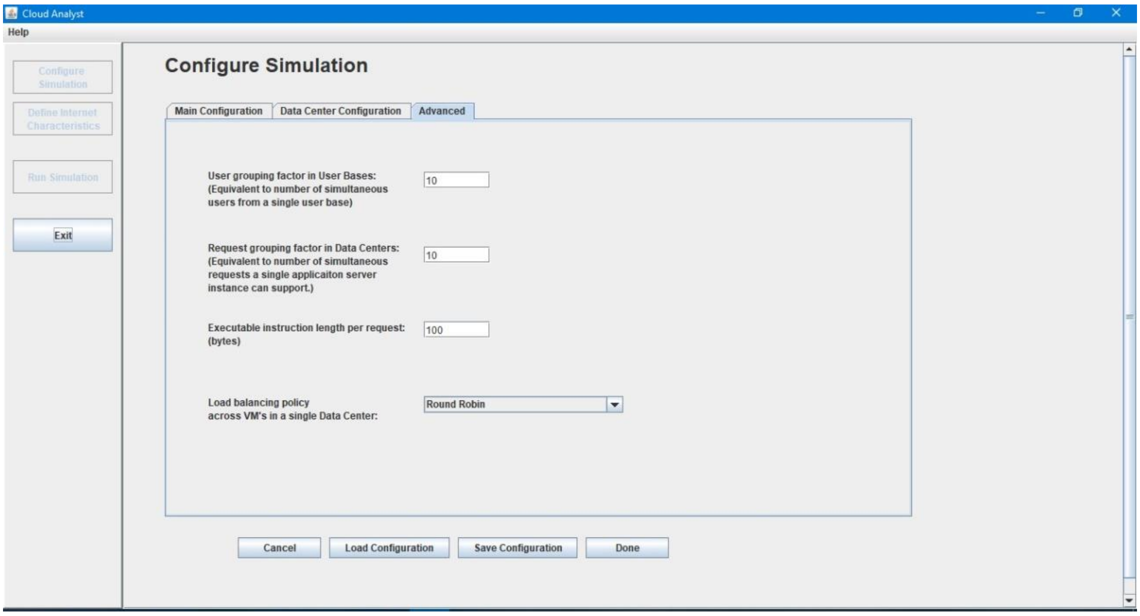


Figure I.3: Illustrates the advanced tab screen with Round Robin load balancing policy

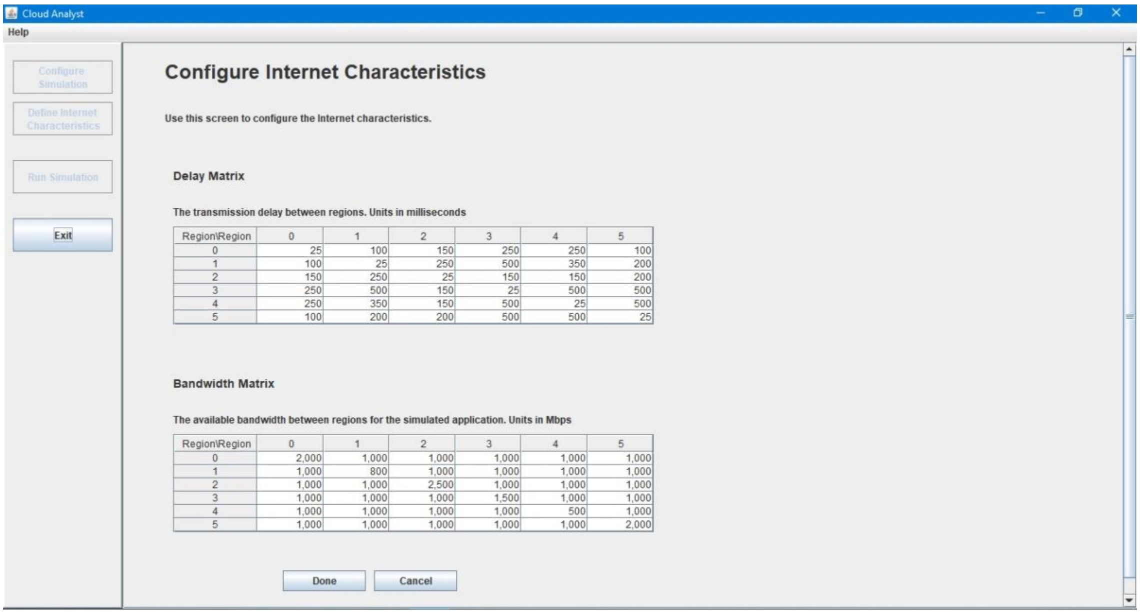


Figure I.4: Illustrates the internet configuration characteristics screen

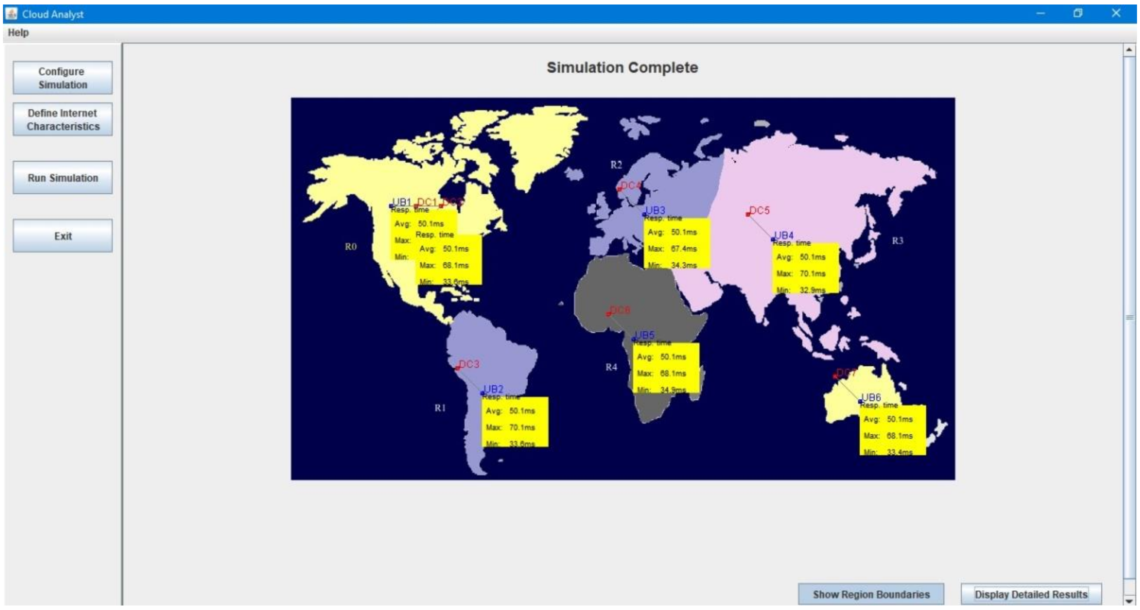


Figure I.5: Illustrates the simulation screen after finished simulation

Case Two Using The Round Robin Load Balancing Policy And Optimize Response Time Service Broker Policy

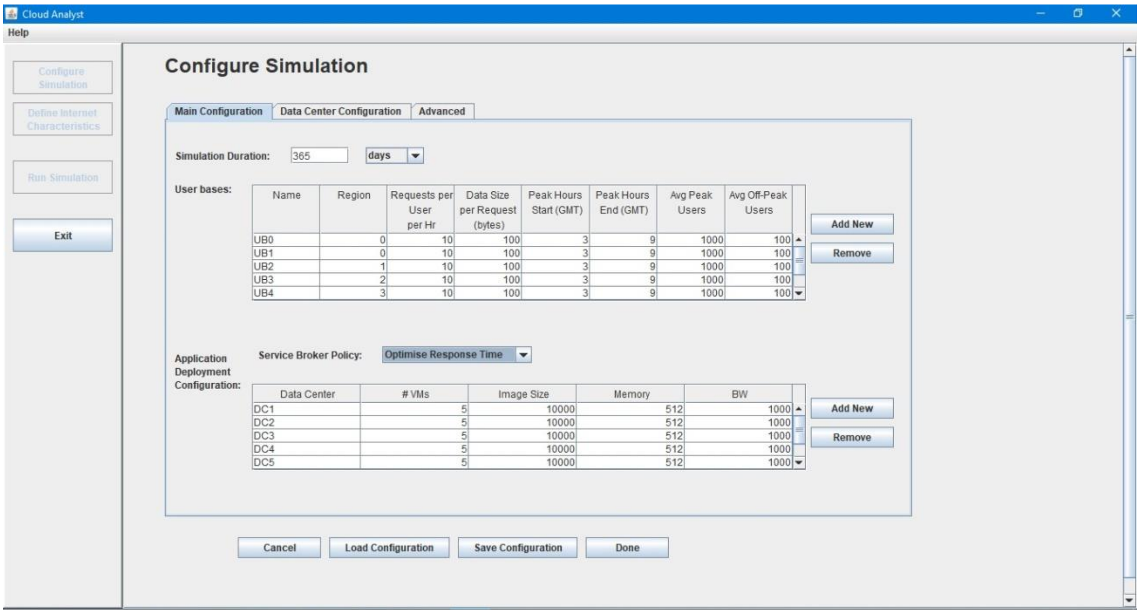


Figure I. 6: Illustrates the main configuration screen using optimize response time policy

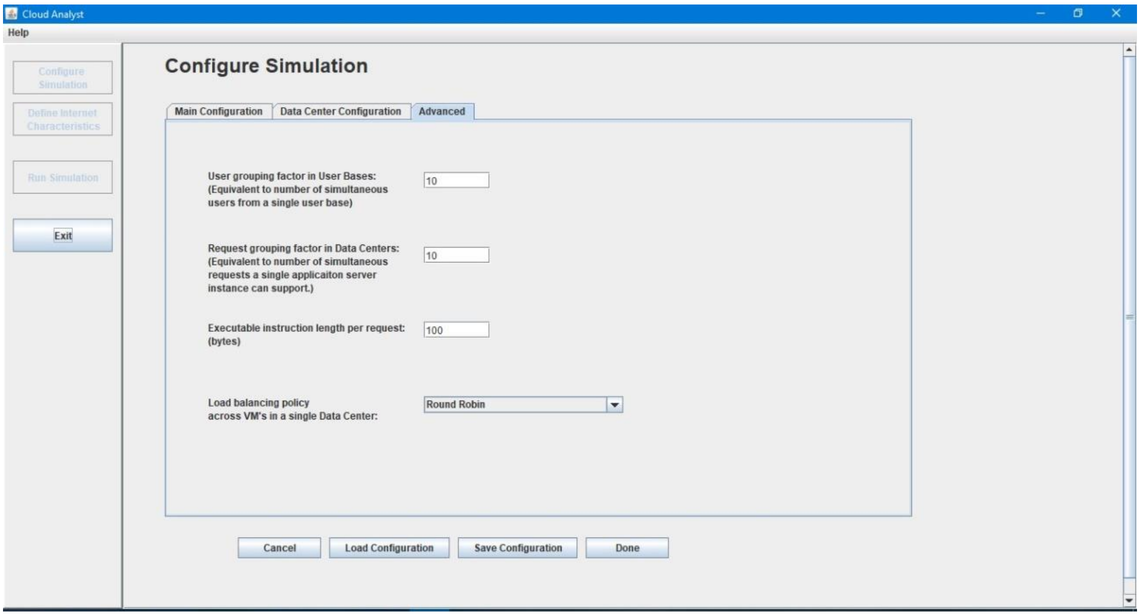


Figure I. 7: Illustrates the advanced tab screen with Round Robin load balancing policy

Case Two Using The Round Robin Load Balancing Policy And Reconfiguration Dynamically Service Broker Policy.

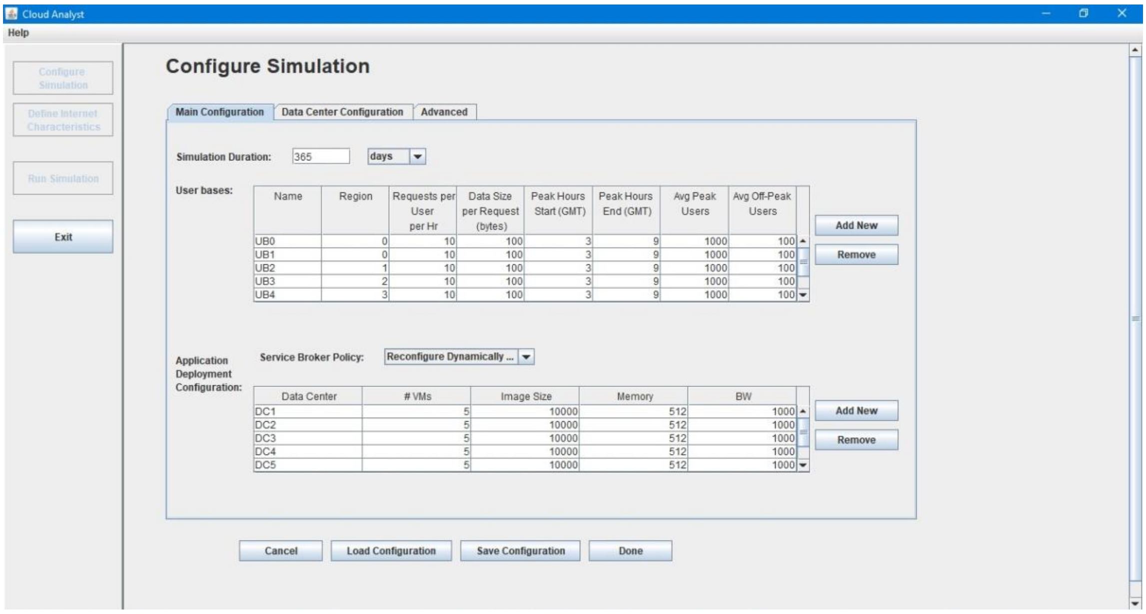


Figure I. 8: Illustrates the main configuration screen using Reconfiguration dynamically policy

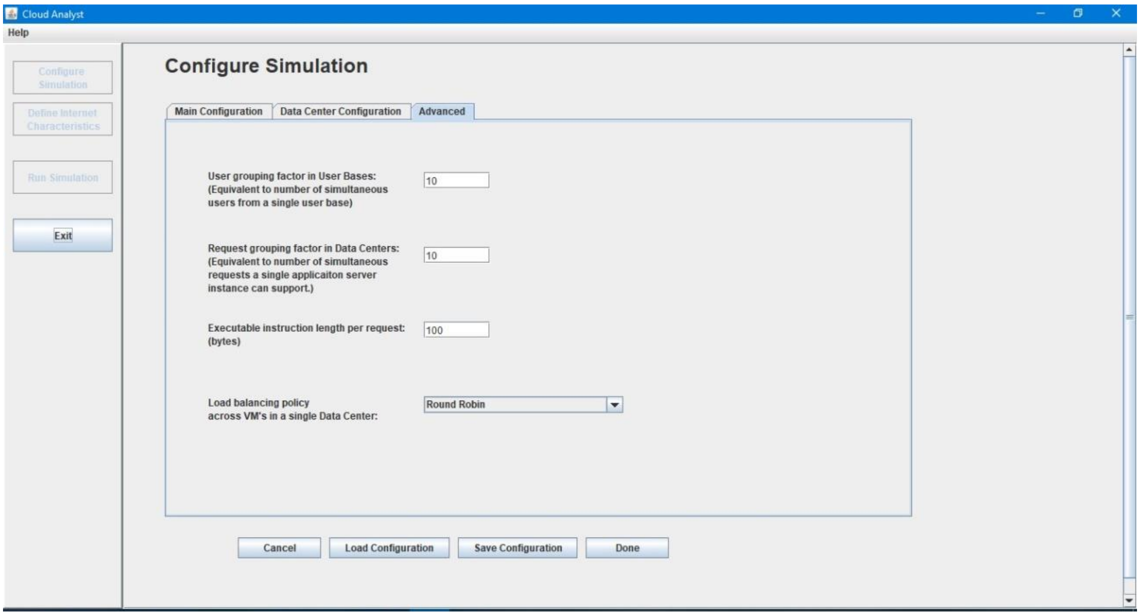


Figure I.9 : Illustrates the advanced tab screen with Round Robin load balancing poli

Case Four Using The Equally Spread Current Execution Location Load Balancing Policy And Closest DC Service Broker Policy.

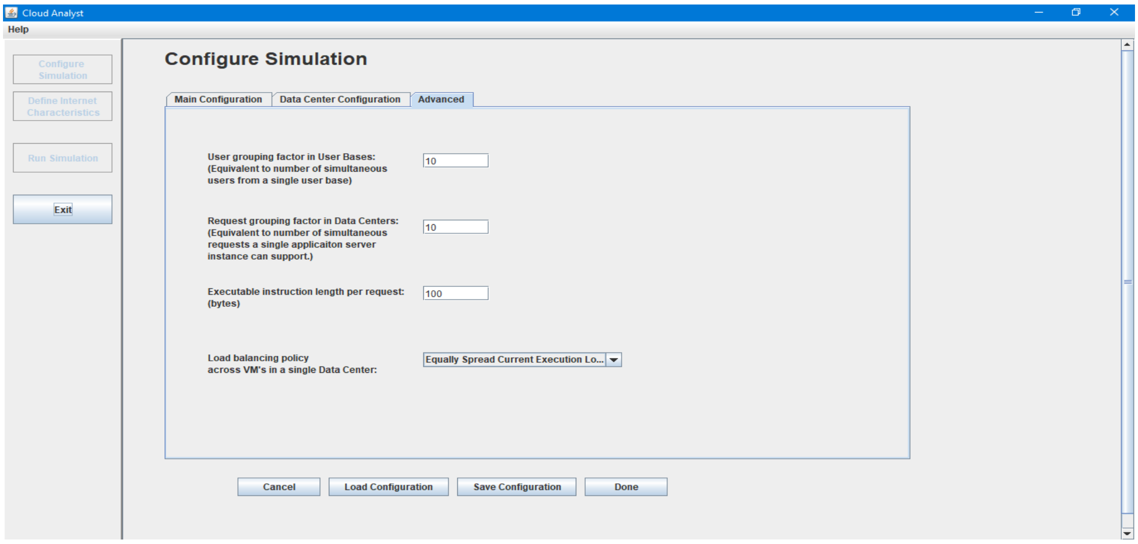
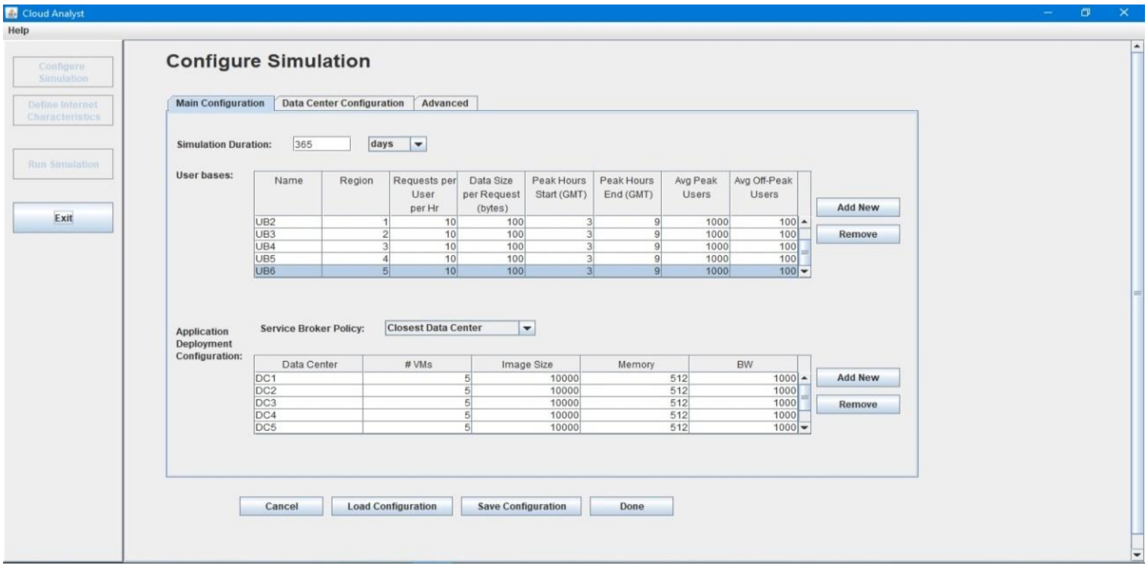


Figure I.10: Illustrates the advanced tab screen with Equally spread current execution location balancing policy



Name	Region	Requests per User per Hr	Data Size per Request (bytes)	Peak Hours Start (GMT)	Peak Hours End (GMT)	Avg Peak Users	Avg Off-Peak Users
UB2	1	10	100	3	9	1000	100
UB3	2	10	100	3	9	1000	100
UB4	3	10	100	3	9	1000	100
UB5	4	10	100	3	9	1000	100
UB6	5	10	100	3	9	1000	100

Data Center	# VMs	Image Size	Memory	BW
DC1	5	10000	512	1000
DC2	5	10000	512	1000
DC3	5	10000	512	1000
DC4	5	10000	512	1000
DC5	5	10000	512	1000

Figure I.11 : Illustrates the main configuration screen using the closest (DC) policy

Case Four Using The Equally Spread Current Execution Location Load Balancing Policy And Optimize Response Time Service Broker Policy.

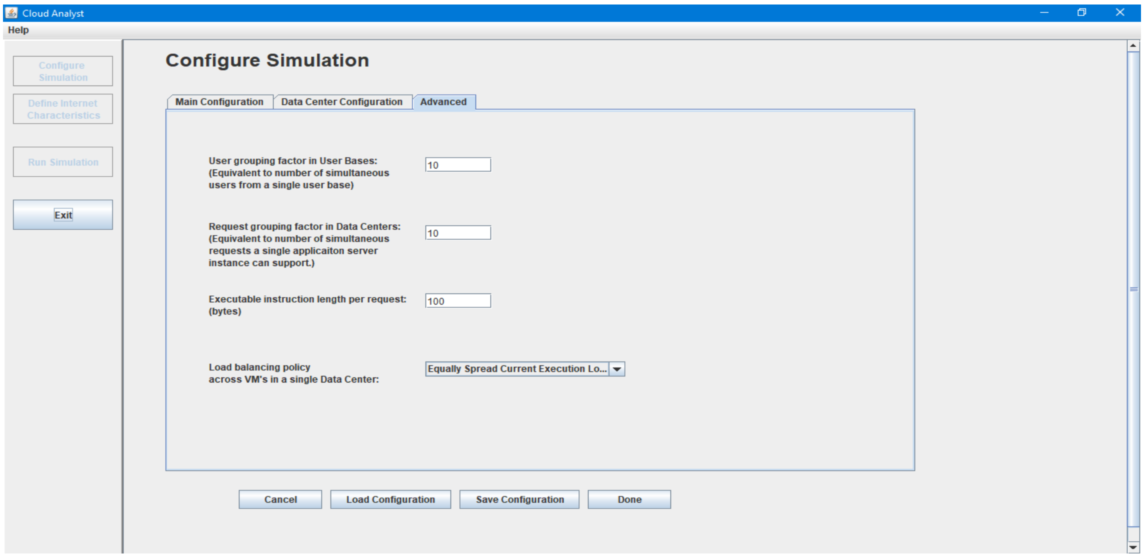


Figure I.12 : Illustrates the advanced tab screen with Round Equally spread current execution location balancing policy

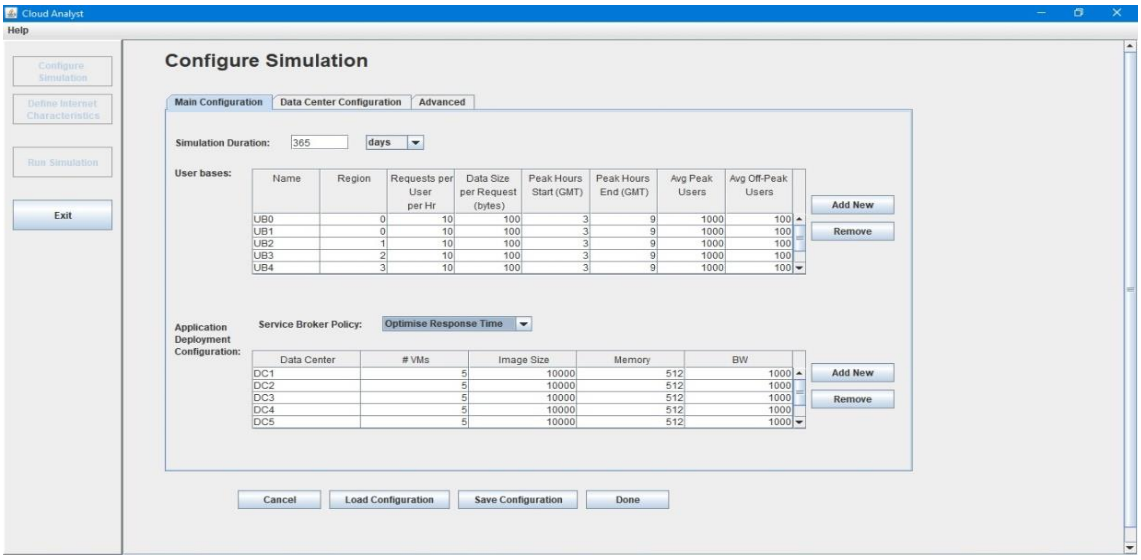


Figure I. 13 : Illustrates the main configuration screen using the optimize Response time policy

Case Four Using The Equally Spread Current Execution Location Load Balancing Policy And Reconfigure Dynamically Service Broker Policy

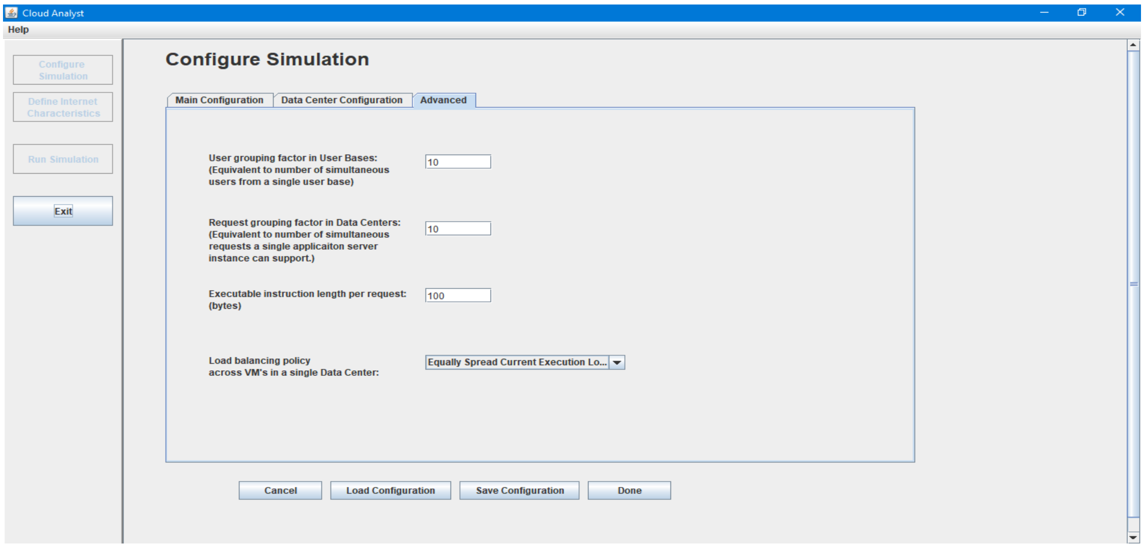
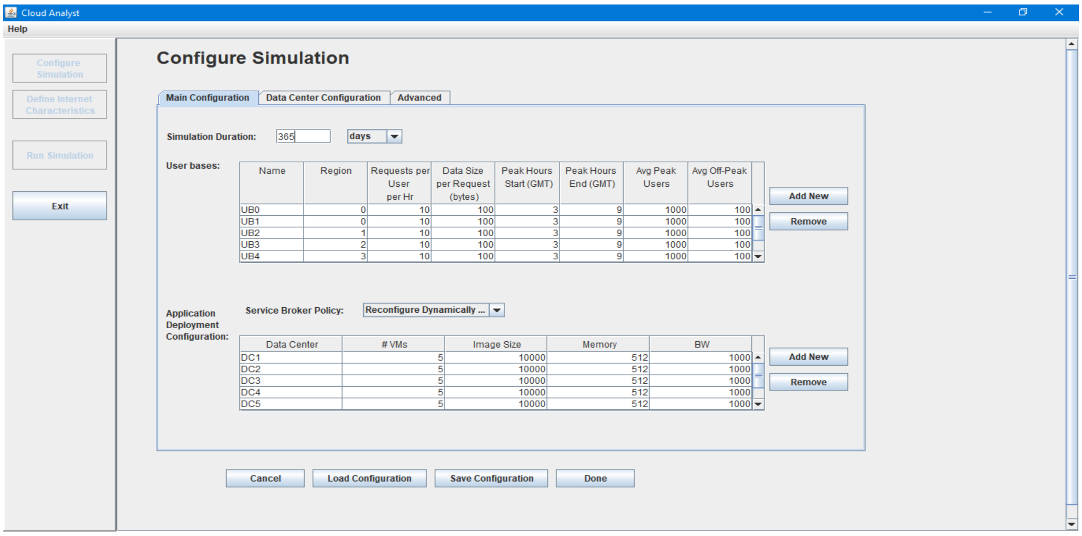


Figure I.14: Illustrates the advanced tab screen with Equally Spread Current Execution location balancing policy



Name	Region	Requests per User per Hr	Data Size per Request (bytes)	Peak Hours Start (GMT)	Peak Hours End (GMT)	Avg Peak Users	Avg Off-Peak Users
UB0	0	10	100	3	9	1000	100
UB1	0	10	100	3	9	1000	100
UB2	1	10	100	3	9	1000	100
UB3	2	10	100	3	9	1000	100
UB4	3	10	100	3	9	1000	100

Data Center	# VMs	Image Size	Memory	BW
DC1	5	10000	512	1000
DC2	5	10000	512	1000
DC3	5	10000	512	1000
DC4	5	10000	512	1000
DC5	5	10000	512	1000

Figure I. 15: Illustrates the main configuration screen using the reconfigure dynamically policy

Case Four Using the Throttled Load Balancing Policy And Closest DC Service Broker Policy

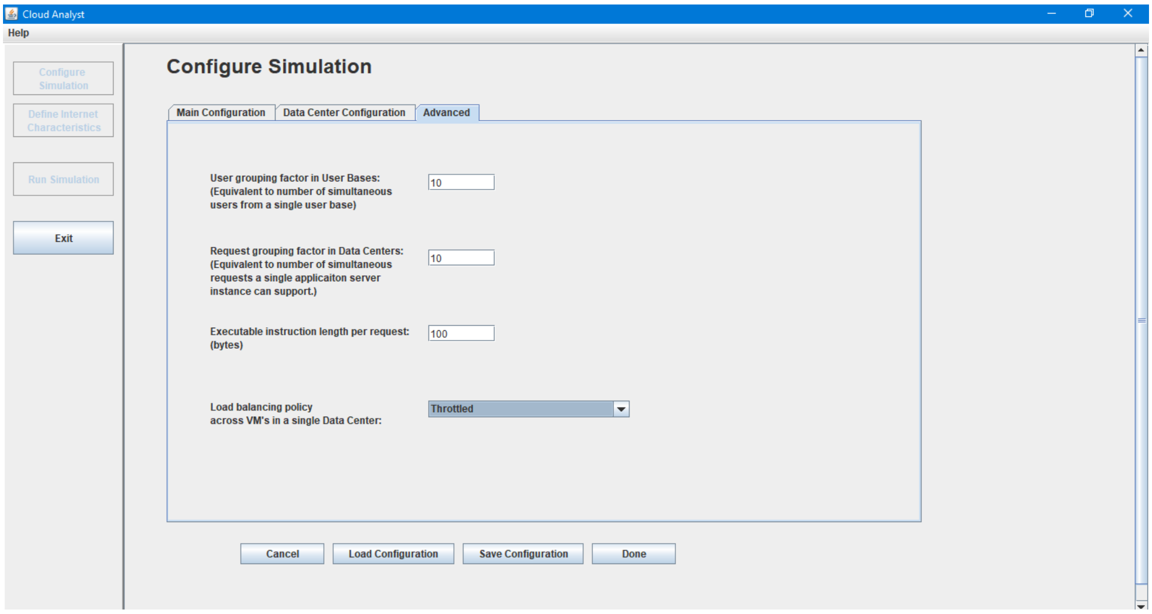
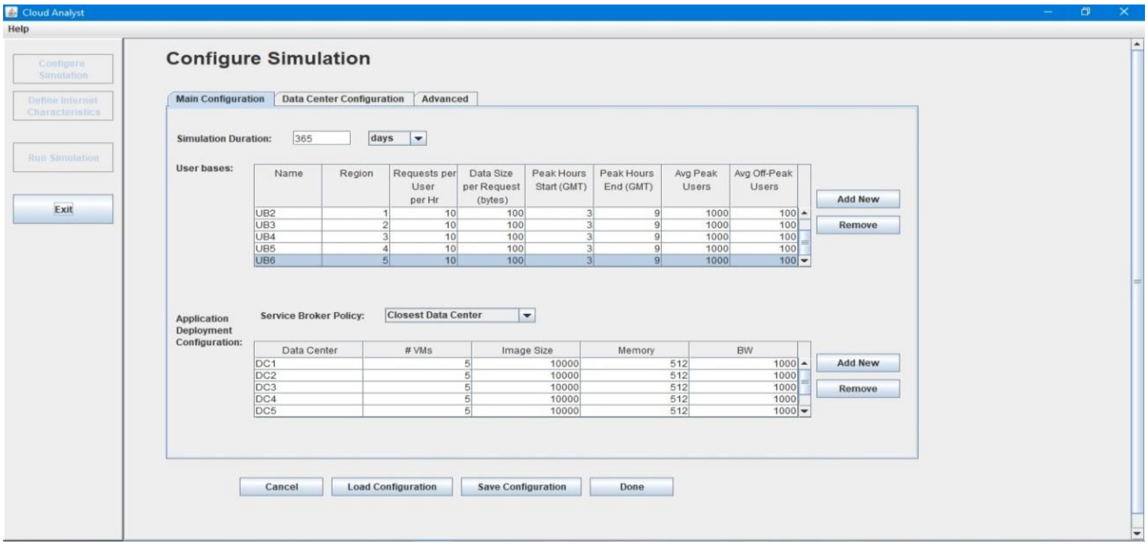


Figure I.16: Illustrates the advanced tab screen with Throttled balancing policy



Name	Region	Requests per User per Hr	Data Size per Request (bytes)	Peak Hours Start (GMT)	Peak Hours End (GMT)	Avg Peak Users	Avg Off-Peak Users
UB2	1	10	100	3	9	1000	100
UB3	2	10	100	3	9	1000	100
UB4	3	10	100	3	9	1000	100
UB5	4	10	100	3	9	1000	100
UB6	5	10	100	3	9	1000	100

Data Center	# VMs	Image Size	Memory	BW
DC1	5	10000	512	1000
DC2	5	10000	512	1000
DC3	5	10000	512	1000
DC4	5	10000	512	1000
DC5	5	10000	512	1000

Figure I. 17: Illustrates the main configuration screen using the closest (DC) policy

Case Four Using The Throttled Load Balancing Policy And Optimize Response Time Service Broker Policy.

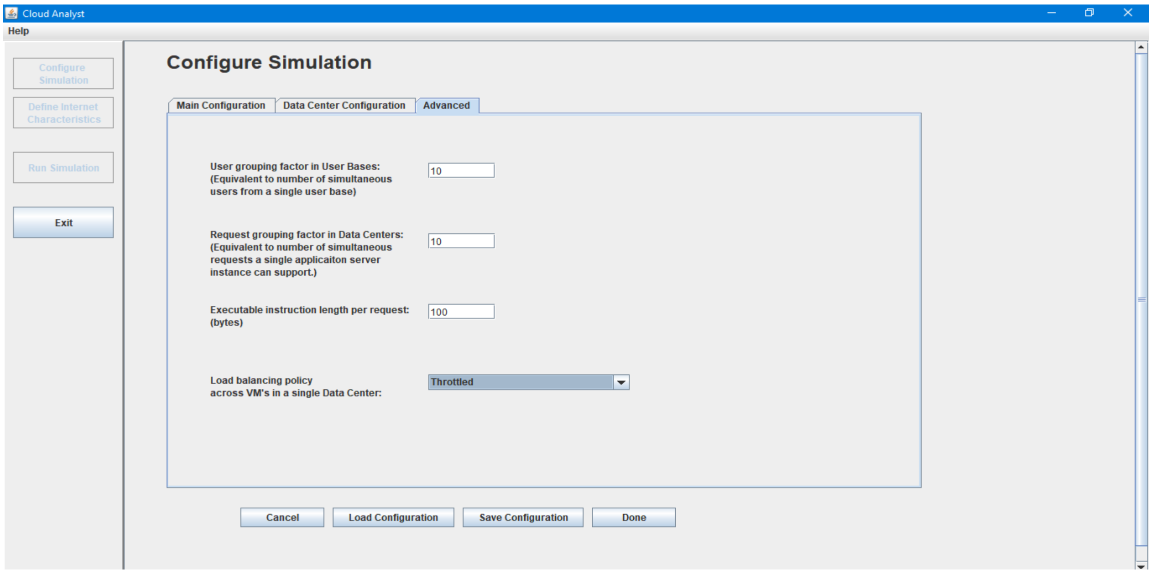


Figure I.18: Illustrates the advanced tab screen with Throttled balancing policy

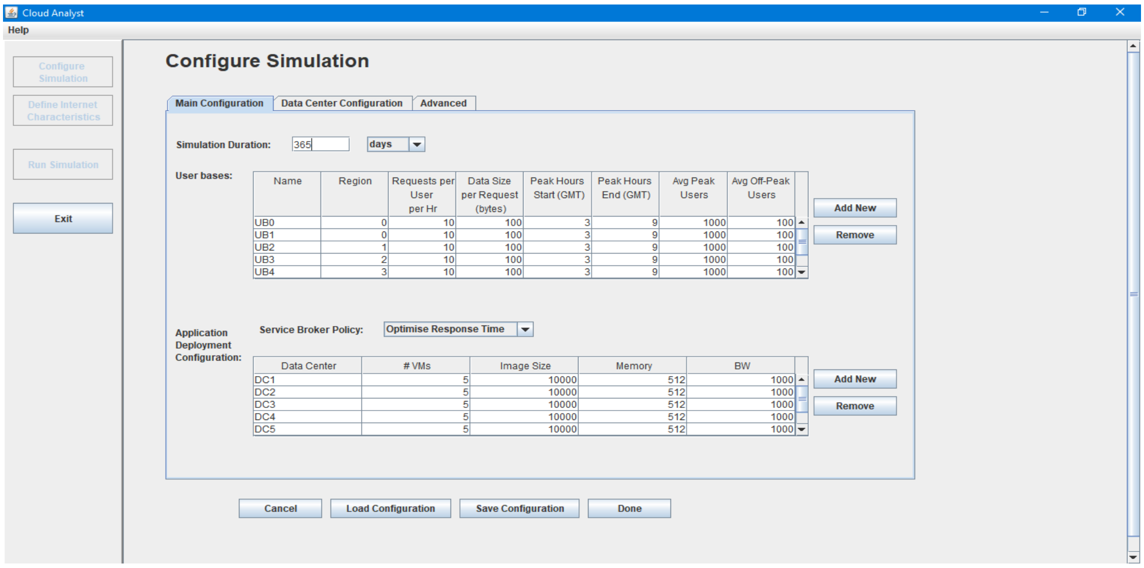


Figure I.19: Illustrates the main configuration screen using the optimize Response time policy

Case Four Using The Throttled Load Balancing Policy And Optimize Reconfigure Dynamically Broker Policy.

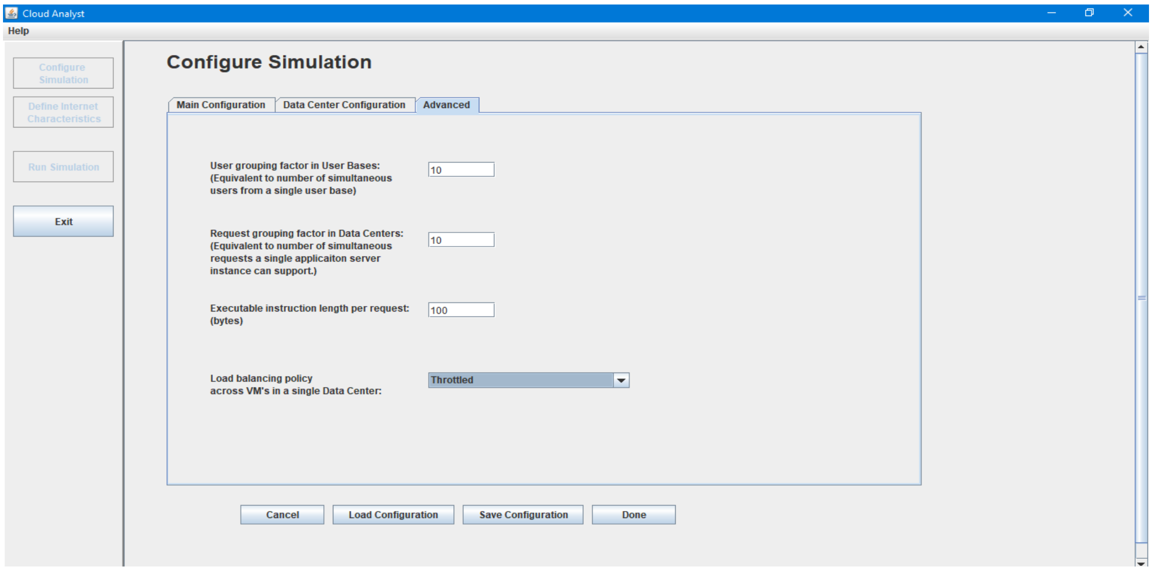


Figure I.20: Illustrates the advanced tab screen with Throttled balancing policy

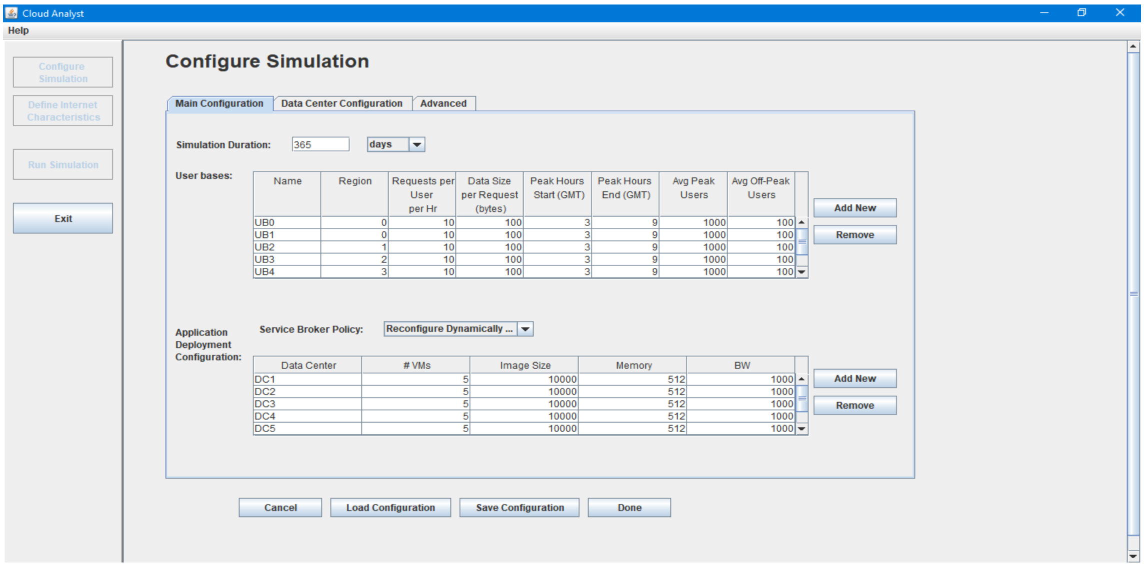


Figure I.21: Illustrates the main configuration screen using the reconfigure dynamically policy

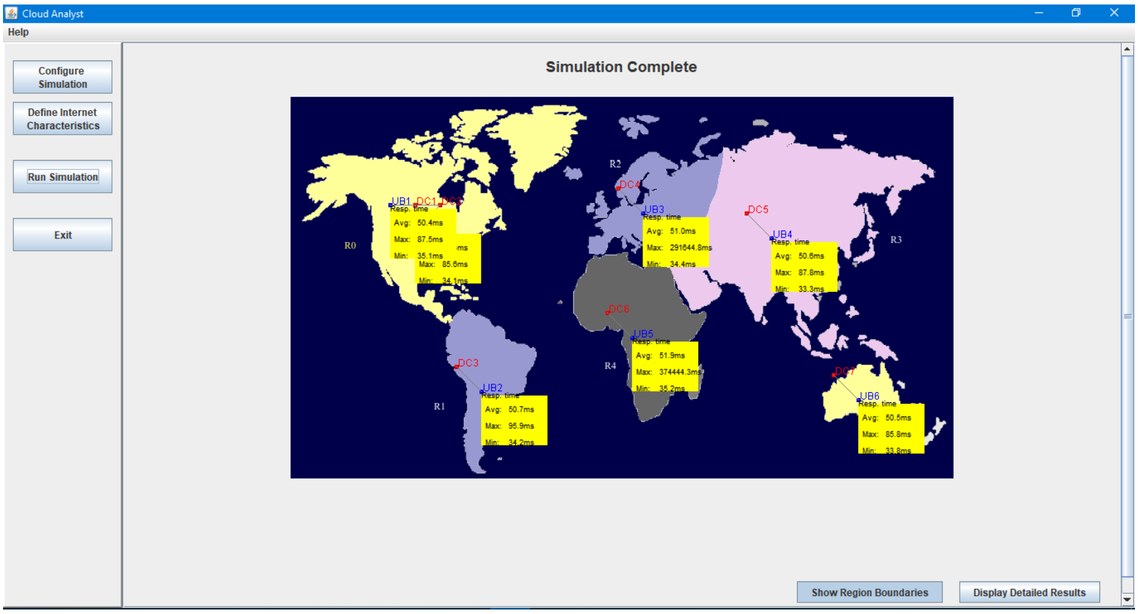


Figure I.22: Illustrates the completion screen of case nine simulation

Appendix II

YAKIN DOĞU ÜNİVERSİTESİ

ETHICAL APROVAL DOCUMENT

Date: 13/01/2020

To the **Graduate School of Applied Sciences**

The research project titled "Simulation of Algorithms and Techniques for Green Cloud Computing using CloudAnalyst" has been evaluated. Since the researcher(s) will not collect primary data from humans, animals, plants or earth, this project does not need to go through the ethics committee.

Title: Mr

Name Surname: Hasan Rafe Hasan Qarqur

Signature:

Role in the Research Project: Researcher

Title: Assoc Prof Dr

Name Surname: Melike Şah Direkoğlu

Signature:

Role in the Research Project: Supervisor

Appendix III

SIMILARITY REPORT

Student Name: Hasan Rafe Hasan Qarqur
Student No: 20184190

Thesis Title: Simulation of Algorithms and Techniques for Green Cloud Computing using CloudAnalyst

Supervisor: Assoc Prof Dr Melike Şah Direkoğlu

Chapters	Percentages
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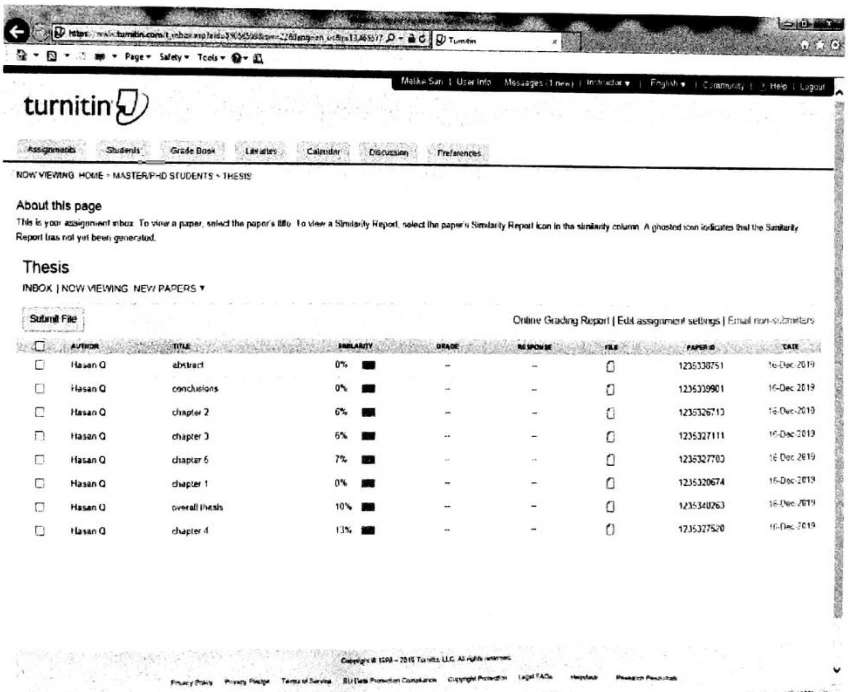
Chapter 2.doc/docx	6%
Chapter 3.doc/docx	6%
Chapter 4.doc/docx	13%
Chapter 5.doc/docx	7%
Chapter 6.doc/docx	0%
*All.doc/docx	10%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