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Analysis and Synthesis of Energy Efficient Techniques in Cloud Computing

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ABSTRACT

With the rapid growth of cloud computing, Datacenter is getting bigger and using more energy. There is a need to develop these efficient energy storage systems to reduce massive energy consumption. In this paper,we focused on reducing energy consumption and has a performance decline due to migration. Different algorithms are analyzed and the Local regression Maximum Correlation (LrMc) is taken which effectively reduces energy consumption in a static and dynamicenvironment.

Keywords: LrMc, DVFS, IqrMc, THrMc, LrMmt

1. INTRODUCTION

In recent years, cloud computing has become widespread in the industry. Widespread adoption of high-capacity networks, low-cost computers and storage devices and hardware virtualization. Without direct active management of the user, there is a need to calculate resources, especially data storage and computing power. Cloud computing provides the infrastructure, operating system and software as a payment model for customers.The recent evolution in information and communication technologies has reinforced our dependence on energy, despite all its benefits. Data centers use a large amount of energy because of its continuous flow, which requires non-stop electricity to operate. Energy efficiency is one of the toughest problems facing in data centers. Reducing energy consumption is critical to reducing the efficiency of data centers. This can be done by adopting various techniques and principles for using less energy in datacenters.

2. RELATED WORK

In [1] the author hasfocused on reducing both Energy consumption and efficiency decay due to migration. The number of cloud providers is growing with advanced and sophisticated services, which is attracting many organizations to join the cloud. Most cloud computing providers use hypervisors to manage virtual machines (VMs) are the main mechanism for the server Integration[2].The data center is which power needed for the continuous operation, requiring non-stop power to operate and cooling. Data center is a resource-rich platform, and planning resources is a challenging task. Cloud refer to a data center where all user needs, such as hardware and software, are provided in the form of pre-configured resources and remote hosted applications[3]. Green Cloud Computing is an approach used to improve the use of computing resources in a cloud computing network, such as storage, servers, its use and reducing services and resources [4]. Cloud SIM is a simulation framework for studying cloud computing systems. Cloud sim is developed to solve the difficulties of performance evaluation of heterogeneous grid systems in Java and for real large-scale distributed environments in a controlled and repeatable fashion[5].

In [6] the author has developed an online optimal framework for balancing the transmission between demand and power consumption by using rigorous optimization approaches. This control framework can shape a variety of choices and operational requirements in the data center.In [7] have focused on designing virtual machines in computer cluster to reduce power consumption through DVFS technique. It converts operating frequencies and voltages of nodes into a cluster without reducing the performance of the virtual machine to acceptable levels. In [8] whileminimizing energy consumption and enrichment while maintaining service level agreements (SLAs) by consolidating public cloud resources, the author proposed an allocation model for private clouds, turning them into green clouds.

In [9] the author has proposed the algorithm by means of detecting the over-loaded and under-loaded host then VM is selected for migration based on the detection and then the VM placement is done. All these detection and selection are done with the help of the algorithm proposed and consolidation policies. Meanwhile, the Service Level Agreement (SLA) is studied and it gets violated when QoS of VM cannot promised. Consolidation techniques are used in the way that SLA would not get violated more. They have used the Multiple Regression algorithm, which consists of the important parameters (CPU, RAM, and BW) and it gives the better results for the host over-load detection. Green Cloud is a sophisticated packet level simulator focused on cloud communications. Green Cloud can be used to create new solutions for monitoring, resource allocation, workload planning and optimization Communication protocols and network infrastructure [10]. Cloud Analyst can be used to analyze the behavior of large-scale Internet use in a cloud environment [11] [21].

Mobile Cloud Computing (MCC) is an emerging technology that integrates cloud computing technology with mobile [12].In [13] the author has discussed about the cloud service providers are keen to provide a substantial amount of computing infrastructure, which is based on the use of designs. This eliminates application high-level startups for application development. On the other hand, there are suppliers of large-scale programming frameworks that create applications, for example, social web work and e-commerce, which are gaining popularity on the Internet. In [14],[15] the authors have proposed a novel Proposed anewapproach to add a barrier to the existing VM integration technique to avoid unnecessary VM migration. [20] The proposed mechanism is to reduce operating and maintenance costs. A new method for energy conservation is the problem of VM integration in cloud datacenters.

In [16] the author has solved the problem of VM integration in cloud data centers. Server integration to reduce operational cost and maintenance cost and increase the effective resource utilization rate of resources. They have proposed a power awareness planning method for selecting high VMs for migration when an engine is considered to be overloaded, which means that the use of this physical machine does not exceed the utility limit. In [17], the author has focused on dynamically allocating resources based on usage analysis and forecasting. This dynamic resource allocation is based on changes in VM, Power Host, VM planning, and Cloudlet planning. [18] The forecaster predicts the required resource and changes the allocation and the utility generator generates the simulated enrichment of a task (Cloudlet). [19] Linear and queuing forecasting models are used and this effectively reduces the energy in the cloud.

The rest of the paper discussed the integration techniques and follow-up actions that improve the overall CPU utilization of the remaining thesis cloud, VM allocation policies such as interquartile range (IQR), threshold policy, local regression (LR) and VM selection policies with minimum migration time (MMT), Maximum Correlation (MC), Maximum Usage Policy (MU) and simulation results are discussed with results and futurework.

3.CONSOLIDATION TECHNIQUES VM CONSOLIDATION TECHNIQUES

To accommodate sudden peak-time load, add more servers in cloud data center. It is often used when the demand is high, to improve overall CPU utilization of new technologies using dynamic integration of Virtual Machines (VMs). When the host is under-utilized, virtual machines from the host are completely relocated to another host and the host is turned off for energy storage.

If the host is overused, one or more virtual machines are selected, and then transferred to another host. There are VM allocation and selection policies to transfer VM from one host to another. the consolidation follows these steps: Determine the history of CPU utilization, its workload can be moved to another machine. Determine when machine is under loaded, original may be shut down or tuned to lower power mode.

3.1 VM Allocation Policies

3.1.1 Dynamic Voltage and Frequency Scaling (DVFS)

It can be used to run processors to reduce power consumption and use different combinations of frequencies with voltages. The energy consumption is approximately proportional to the square of the processor frequency and processor voltage. Reducing the processor voltage and frequency will reduce the efficiency of the processor, the efficiency is not that important, it can reduce the processor power consumption by reducing the processor voltage and frequency.

The power consumption of the integrated circuits is proportional to the simple formula fc (v ^ 2), where f is the frequency, c is the capacitance and v is the voltage. DVFS enables integrated circuit storage in different combinations. The voltage distribution can be increased or decreased depending on the circumstances. DVFS can dynamically reduce supply voltage andwork frequency to reduce energy consumption, while simultaneously meeting performance requirements.

3.1.2Inter Quartile Range (IQR)

This is a strong statistic for defining the upper threshold for CPU usage. It is a measure of statistical scatter, which is calculated by subtracting the third and first quarters. IQR = Q3 - Q1 Similar to MAD, the threshold in IQR can be set as given in equation 1.

UtilizationThreshold= 1 – s.IQR (1)

where s is the safety parameter and it describes the rate

ofVm consolidation. If the data is symmetrically distributed then half value of IQR is same as the Median Absolute Deviation (MAD) value for that data.

3.1.3 Threshold Policy (THR)

The value of Utilization Threshold formula is given in equation 2.

Utilization threshold =1-s.THR(2)

3.1.4 Local regression (Lr)

This method uses LOESS procedure to approximate a curve is given in equation 3.

g(x) = a+b.x(3)

by using the CPU utilization history. The curve generated is a straight line and the slope is used to estimate the situations of loading. The CPU utilization threshold is decided by equation 4.

$$s.\ g(xk+1) \geq 1 \qquad (4)$$

set state as overloaded xk+1 − xk ≤ tm.Wheres is the safety parameter, g(xk+1) is the estimated next observation for CPU utilization.

3.2 VM Selection Policies

3.2.1 Minimum Migration Time (MMT)

It takes a minimum of time to find a virtual machine, transfer its workload to another machine, and compare it to a physical machine or other virtual machine assigned to the host. It then migrates a VM, which requires a minimum amount of time to complete a migration. Migration time is estimated as the amount of RAM used by VM, divided by the spare network bandwidth available to the host.

3.2.2 Maximum correlation Policy (Mc)

It sees the degree of interaction or similarity between resource usage with applications and other machines running on an additional subscription server that needs to be migrated from a virtual machine. The higher the number of contacts, the higher the probability of server overloading.

3.2.3 Maximum utilization Policy (Mu)

The choice of VM is based on the current application status of virtual machines running on a physical machine. If the application is below the threshold value selected, it is marked as a low utility host.

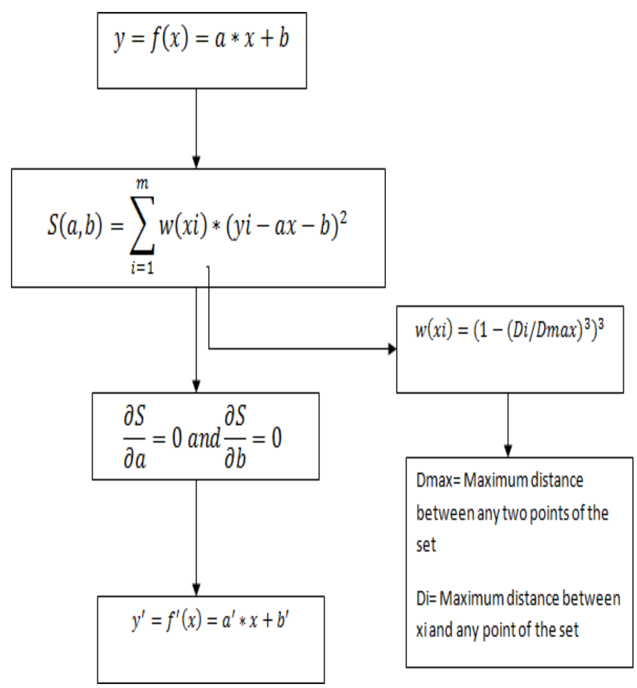
3.3 Local Regression Maximum Corrleation

For LrMc, the local regression (LR) is the VM allocation policy, which is the detection policy and the maximum correlation (mech) VM selection policy. VMs that have the highest correlation of CPU usage with other VMs (1) will migrate. LRMC is the method used, which effectively reduces energy consumption compared to all other methods. Performance decomposition due to VM migration was also calculated. The choice of VM is based upon the current application status of virtual machines.

The main idea of the local regression method is to apply simple models to the localized subsets of the data to create a curve that approximates the original data and is shown in the figure. 1. The neighboring weights are

(2) Where s is the safety parameter, T

Figure 1: Flowchart of Local regression



assigned using the Monitoring (‘,) Tricube weight function, which is given by the formula in equation 5.

$$T(u) = (1-|u|^3)^3;\ \text{if } |u| < 1$$
$$0 \qquad ;\ \text{otherwise}(5)$$

Let Δ (x) = | – x| be the distance from x to xi, and let Δ

(x) be these distances ordered from smallest to largest. Then the neighborhood weight for the observation (’) is defined by the function (x)

(x)= T [(Δ) (x)/Δ (x)] for such that Δ (x) <Δ (x), where q is the number of observations in the subset of data localized around x. The size of the subset is defined by a parameter of the method called the bandwidth. The parametric family of functions is y = a + bx. The line is fitted to the data using the weighted least squares method with weight (x) at (’). The values of a and b are found by minimizing the function, the formula is given in equation6.

$$\sum_{i=1}^{n} w_i\,(x)(y_i - a - b\,x_i)^2 \qquad (6)$$

3.4 Simulation Results and Discussion

The algorithms such as DVFS, IqrMc, ThrMc, LrMmt, LrMu are taken and compared. The outputs are taken both in the static and dynamic environment.

Steps to be followed are:

- First create a data center and hosts with a desiredspecification.
- Then create a data center broker and the virtual machines needed for theapplications.
- Next, allocate the created host and cloudlets to the virtualmachines.
- Then submit the cloudlet and the VM list to thebroker.
- Set the workload and start thesimulation.
- Calculate the utilization and energy consumed for theworkload.
- After the completion of the task stop thesimulation.

The inputs are given as follows

IVM Description
II. Cloudlet properties
MIPS –250Length - 40000 MI RAM - 2048 MBHost DescriptionMIPS – 10000RAM - 2048 MB
PDM is calculated by using the equation 7

$$\frac{1}{M}\sum_{j=1}^{M}\frac{C_{dj}}{C_{rj}} (7)$$

Where, M is the number of VM, $C_{dj}$is the estimate of the performance degradation of the Vm, j caused bymigration,$C_{rj}$is thetotalCPU capacityrequestedbythe Vm, j duringits lifetime.The algorithms which are mentioned above are analyzed and the existing algorithm and the modified algorithm are compared.

3.4.1 Simulation Outputs in Static Environment

3.4.1.1 DVFSAlgorithmoutput

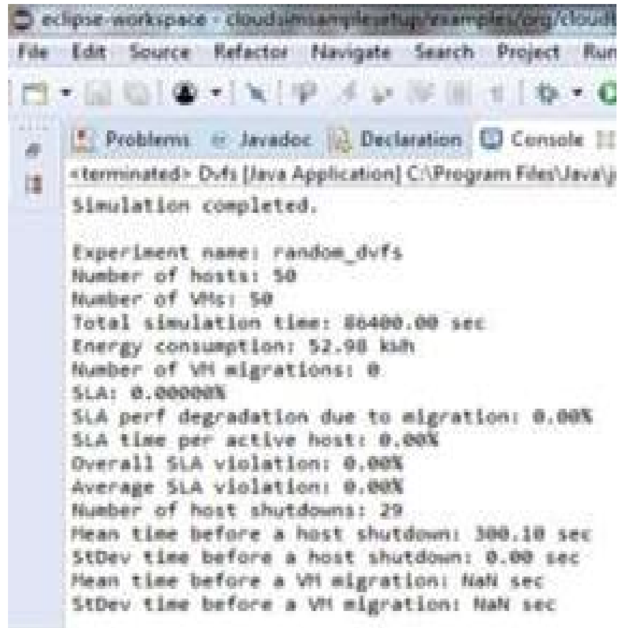


Figure 2: DVFS in static environment

3.4.1.2 IqrMcAlgorithm output

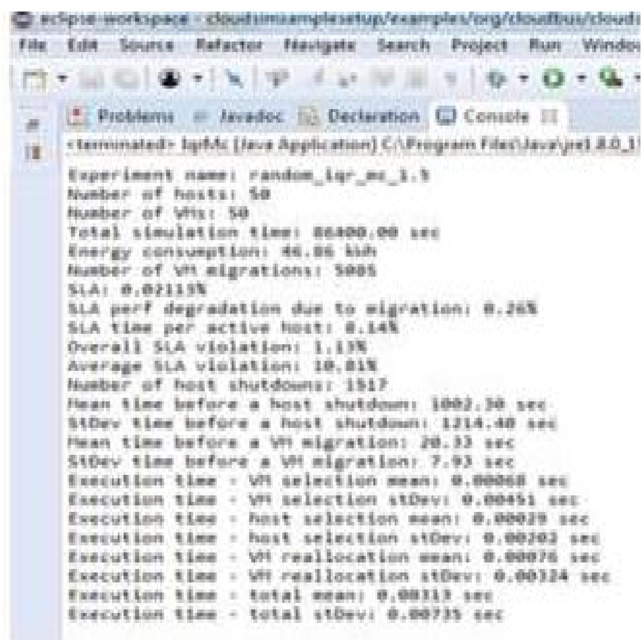


Figure 3: IqrMc in static environment

3.4.1.3 ThrMcAlgorithmoutput

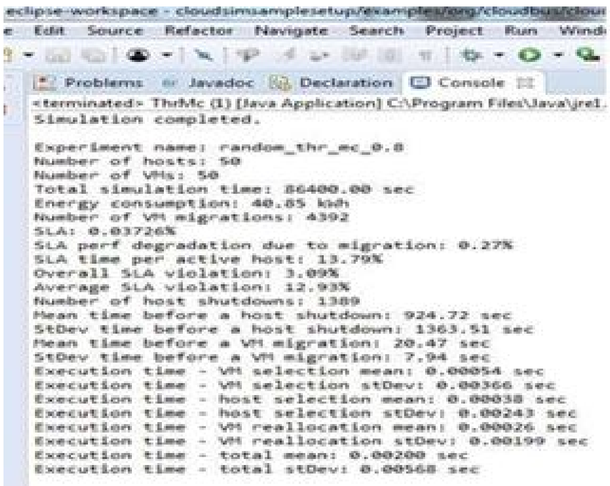


Figure 4: ThrMc in static environment

3.4.1.4 LrMmt Algorithmoutput

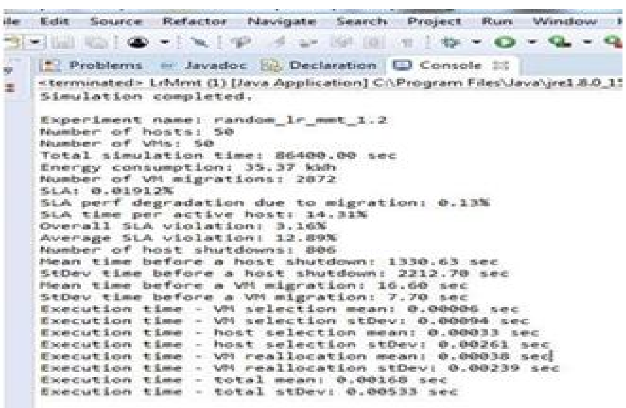


Figure 5: LrMmt in static environment

3.4.1.5 LrMu Algorithm output

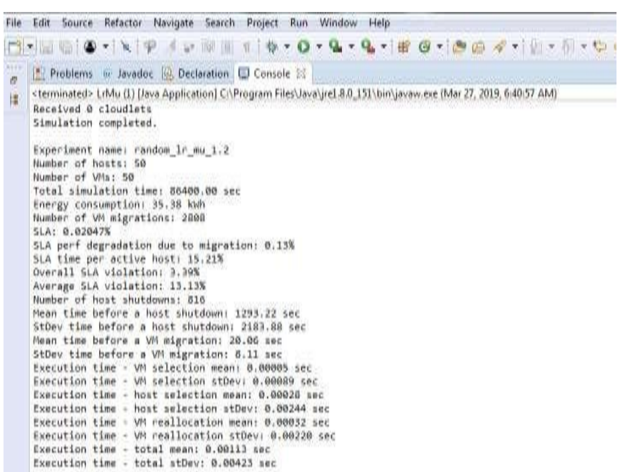


Figure 6: LrMu in static environment

In Figure.2, the energy consumption is found to be 52.98 kWh, PDM is 0 (%) and the number of Vm migration is also 0 are obtained from the DVFS algorithm. In Figure.3, the energy consumption is found to be 46.86 kWh, PDM is 0.26 (%) and the number of Vm migration is 5085 are obtained from the IqrMc algorithm. In Figure.4, the energy consumption is found to be 40.85 kWh, PDM is 0.27 (%) and the number of Vm migration is 4392 are obtained from the ThrMc algorithm. In Figure.5, the energy consumption is found to be 35.37 kWh, PDM is 0.13 (%) and the number of Vm migrations is 2872 are obtained from the LrMmt algorithm. From Figure.6, the energy consumption is found to be 35.38 kWh, PDM is 0.13 (%) and the numberof Vm migration is 2808 from the LrMualgorithm.

3.4.2 Comparison of DVFS, IqrMc, ThrMc, LrMmt, LrMu

Table 1: Results obtained by different algorithms with the parameters considered in the static environment

Parameters	DVFS	IqrMc	ThrMc	LrMmt	LrMu
EC (kWh)	52.98	46.86	40.85	35.37	35.38
Number of Vm migrations	0	5085	4392	2872	2808
PDM (%)	0	0.26	0.27	0.13	0.13

Comparison of DVFS, IqrMc, ThrMc, LrMmt, LrMu is shown in Table 1.

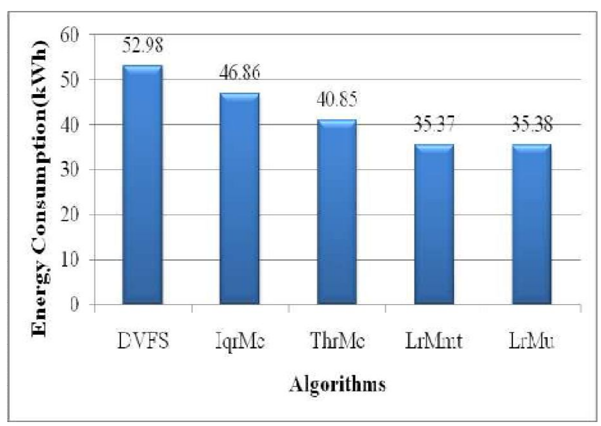


Figure 7: Algorithms and their energy consumptions

From Figure. 7 LrMc is chosen among the algorithms.Some parameters taken into consideration are modified are as follows :

- **Safety parameter**

It is the parameter which determines how effectively the system consolidates the Vm. If the safety parameter is low then the energy consumption is also less is shown in Table 2.

Parameters fixed in the above result obtained are Number of hosts = 50, Number of Vms = 50, Scheduling interval = 300ms

Table 2: Results obtained in the static environment (safety parameter)

Safety parameter (ms)	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3
EC (kWh)	18.37	20.17	22.16	24.33	26.78	29.07	31.89	34.35	36.62
Vm migrations	259	270	570	873	1307	1460	2203	2203	2702
PDM (%)	0.02	0.02	0.06	0.09	0.13	0.13	0.14	0.14	0.15

- **Vmmigration**

Parameters fixed in the above result obtained are Number of hosts = 50, Safety parameter = 1.2, Scheduling interval = 300ms is shown in Table 3.

Table 3: Results obtained in the static environment (number of Vms)

Number Vms	10	20	30	40	50	60	70	80	90	100
EC (kWh)	7.95	13.59	21.15	26.95	34.35	39.97	47.09	52.86	59.23	63.46
sVm migration	336	616	1160	1735	2203	2944	3532	4206	4541	4651

- **Schedulinginterval**

It is the time interval in which the particular set of instructions or applications would receive to the machine.

Parameters fixed in the above result obtained are Number of hosts = 50, Number of Vms = 50, Safety parameter = 1.2 is shown Table 4.

Table 4: Results obtained in the static environment (scheduling interval)

Scheduling interval	300	400	500	600	700	800	900
EC (kWh)	34.35	34.34	34.33	34.01	34.11	34.07	34.17
Vm migrations	2203	1656	1329	1123	974	889	816
PDM (%)	0.14	0.10	0.08	0.07	0..06	0.05	0.05

3.4.3 Existing LrMc Algorithm

Number of hosts = 50, Number of Vms = 50, Safety parameter = 1.2, Scheduling interval = 300ms.

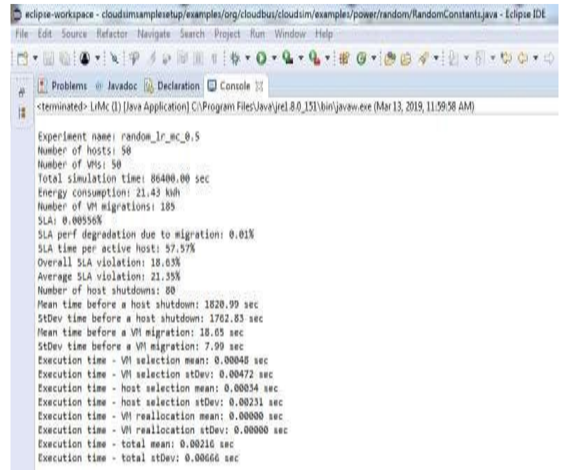


Figure 8: Existing LrMc in static environment

From the output obtained from the existing LrMc, the energy consumption is found to be 34.35 kWh, PDM is 0.14 (%) and the numberofVm migration is 2203 is shown in Figure.8.

3.4. 4 ModifiedLrMc Algorithm

The LrMc with changes in the parameters, when a safety parameter is low, the energy consumption is less and the scheduling interval is also changed to 900ms.

Number of hosts = 50, Number of Vms = 50, Safety parameter = 0.5, Scheduling interval = 900ms

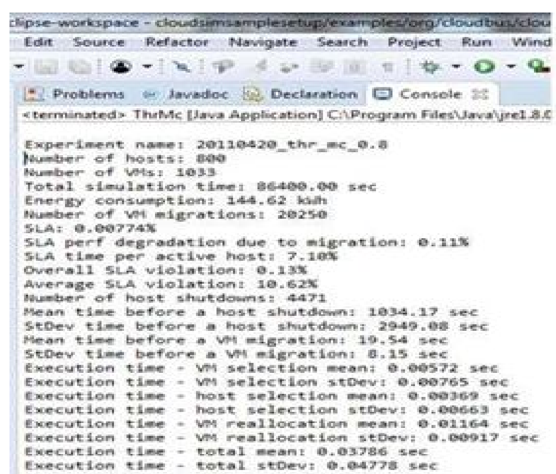


Figure 9: Modified LrMc in static environment

From the output obtained from the modifiedalgorithm of LrMc, the energy consumption is found to be 21.43

kWh, PDM is 0.01(%) and the numberofVm migration is 185 is shown in Figure.9. The energy consumption and performance of existing and modified LrMc in static environment is shown in Figure.10 and Figure. 11respectively

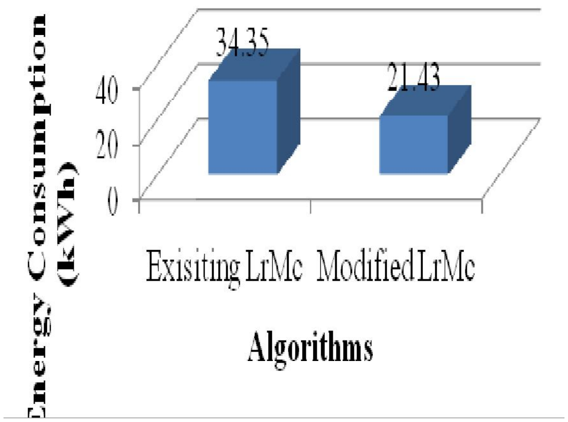


Figure 10: Energy Consumption of existing and modified LrMc in static environment

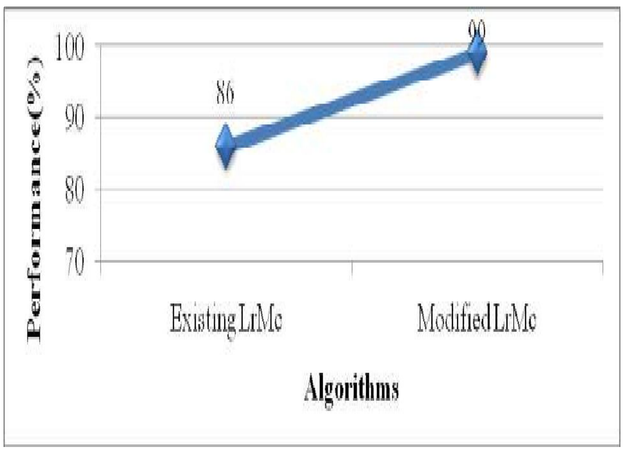


Figure 11: Performance of existing and modified LrMc in static environment

3.5 SIMULATION IN DYNAMIC ENVIRONMENT

Next the outputs are taken in the planet lab workload which is dynamic in nature and the workload**"20110420"**istaken from the same algorithms which is chosen for the static environment such as DVFS, ThrMc, ThrMmt, LrMmt, LrMu are considered and their respective simulations were performed and finally, existing LrMc and the proposed algorithms are compared with the energy consumption and their performance.

3.5.1 DVFSAlgorithmoutput

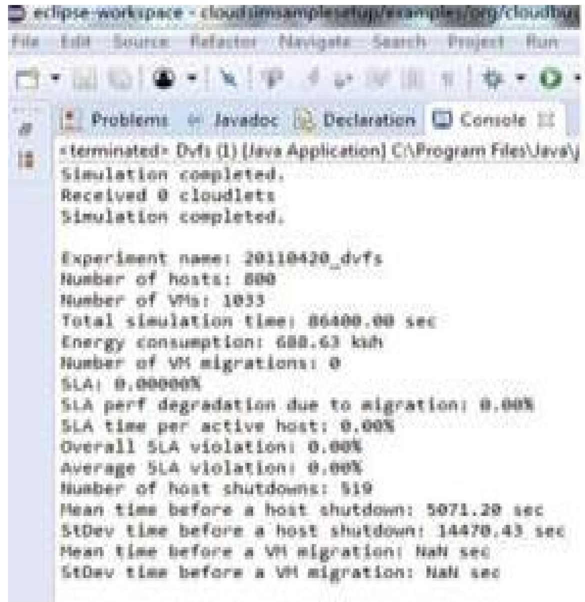


Figure12:DVFS in dynamic environment

3.5.2 IqrMc Algorithmoutput

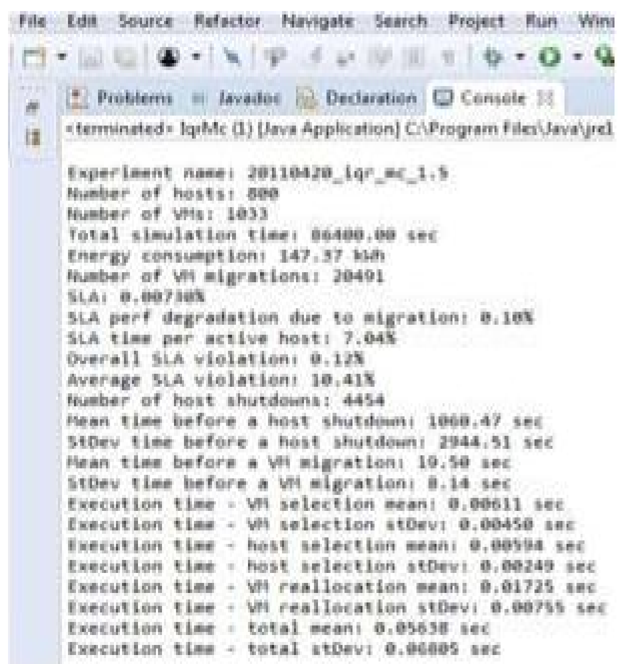


Figure 13: IqrMc in dynamic environment

3.5.3 ThrMcAlgorithmoutput

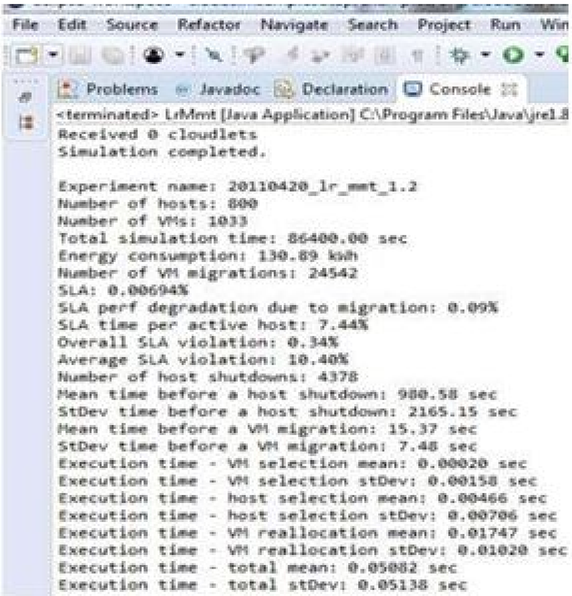


Figure.14: ThrMc in dynamic environment

3.5.4 LrMmt Algorithmoutput

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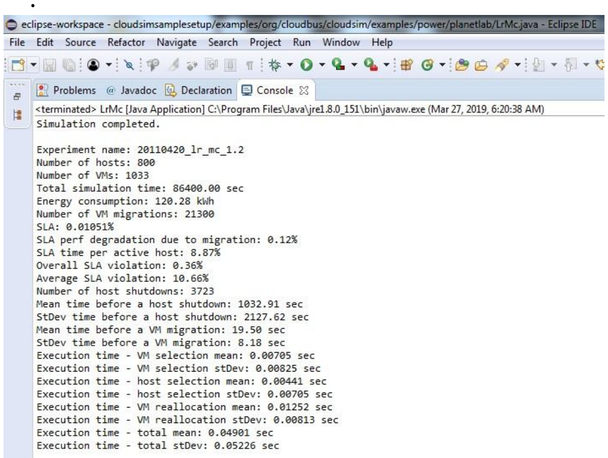
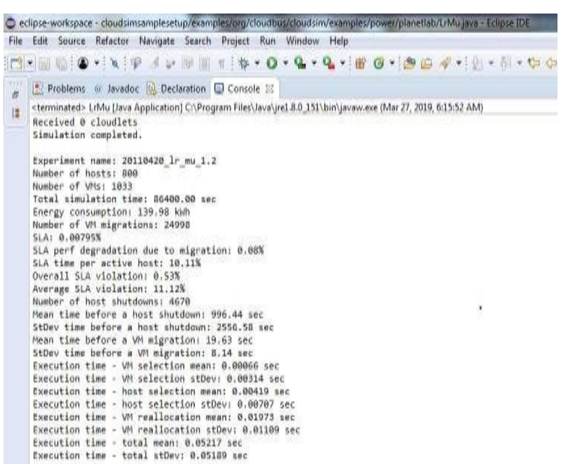


Figure 15: LrMmt in dynamic environment



3.5.6 LrMu Algorithm output

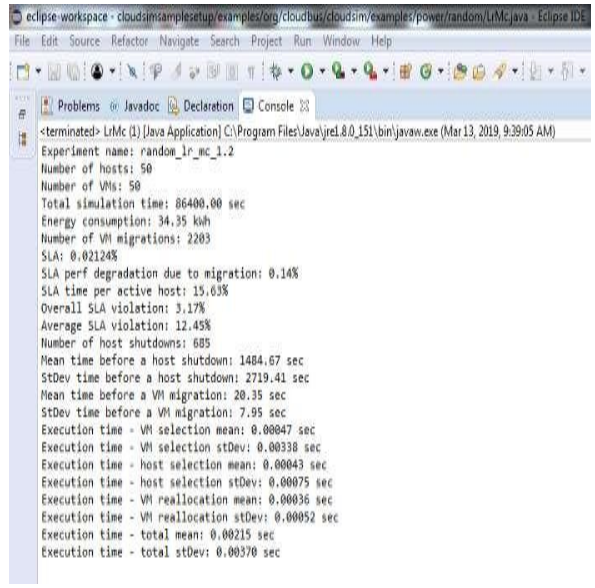


Figure 16: LrMu in dynamic environment

In Figure.12 the energy consumption is found to be 688.63 kWh, PDM is 0 (%) and the number of Vm migration is 0 are obtained from the DVFS algorithm. In Figure.13 the energy consumption is found to be 147.37 kWh, PDM is 0.10 (%) and the number of Vm migration is 20491 are obtained from the IqrMc algorithm. In the Figure.14 the energy consumption is found to be 144.62 kWh, PDM is 0.11 (%) and the number of Vm migration is 20250 are obtained from theThrMcalgorithm.InFigure.15theenergyconsumption isfoundtobe130.89kWh,PDMis0.09(%)andthenumber ofVmmigrationis24542areobtainedfromtheLrMmtalgorithm.From the output obtained in Figure.16 the energy consumption is found to be 139.98 kWh, PDM is 0.08 (%) and the number of Vm migration is 24998 from the LrMu algorithm.

3.5.7 Existing LrMc Algorithm output

Figure 17: Existing LrMc in dynamic environment

From the Figure.17 the output obtained from the existing LrMc algorithm, the energy consumption is found to be 120.28 kWh, PDM is 0.12 (%) and the number ofVm migration is 21300.

3.5.8 Modified LrMc Algorithm output

The LrMc with some changes as mentioned above in the static is done here.

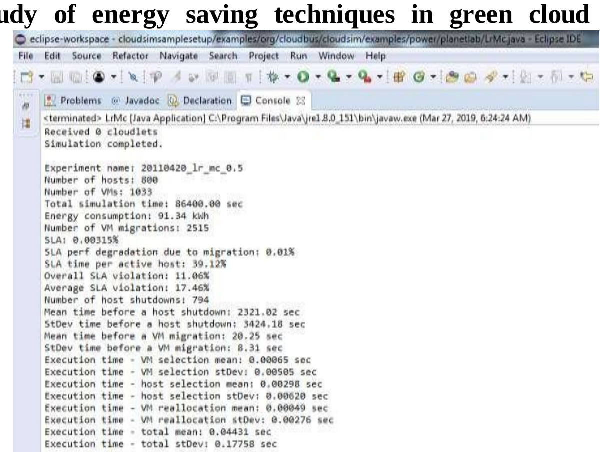


Figure 18: Modified LrMc in dynamic environment

From Figure.18 the output obtained from the modified algorithm of LrMc, the energy consumption is found to be 91.34 kWh, PDM is 0.01 (%) and the numberofVm migration is 2515. The energy consumption and performance of existing and modified LrMc in static environment is shown in Figure.19 and Figure. 20 respectively.

3.5.9 Results obtained in planet lab workload

Results obtained in planet lab workload is shown in Table 5.

Table 5: Results obtained by different algorithms in dynamic environment

Algorithms	Energy Consumption (kWh)	Vm migrations	PDM (%)
DVFS	688.63	0	0
IqrMc	147.37	20491	0.10
ThrMc	144.62	20250	0.11
LrMu	139.98	24998	0.08
LrMmt	130.89	24542	0.09
Existing LrMc	120.28	21300	0.12
Modified LrMc	91.34	2515	0.01

3.5.10 Comparison of algorithms in dynamic environment

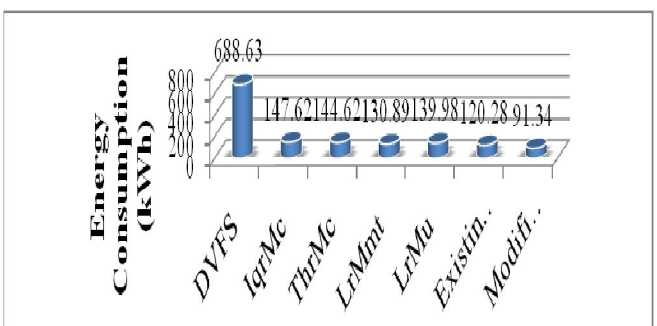


Figure 19: Energy consumption comparison graph

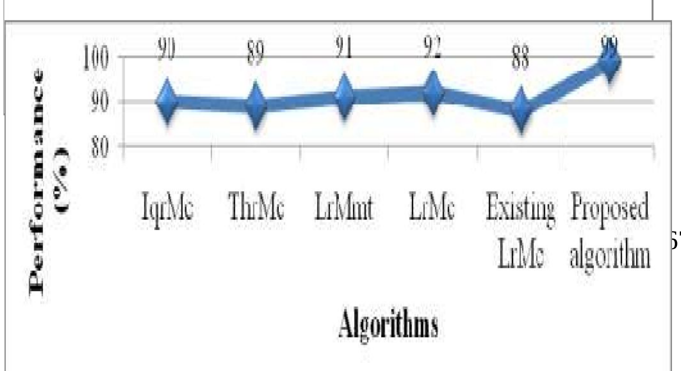


Figure20: Performance comparison graph

4. CONCLUSION AND FUTURE WORK

Cloud computing is the new era of computing applications, which provides applications as a model for what you pay for. IT services are growing rapidly due to cloud computing, and its complexity is decreasing. Cloud technologies focus on new methods and principles to effectively manage the cloud infrastructure. Energy consumption is a major concern in modern servers and data centers. Different workload types and applications vary, so different servers may have different energies. Moreover, the computing industry is integrating personal servers with efficient mechanisms to reduce server power. In this paper, the Local regression Maximum correlation (LrMc) algorithm is modified and the energy consumption reduction in the data centers is efficiently achieved. In addition, with the help of this method, performance decay is also reduced. In the future, the Service Level Agreement (SLA) in addition to energy consumption may be considered. The SLA value should be low for bestperformance.

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