DYNAMICS RESOURCE ALLOCATION VIA VIRTUAL MACHINE FOR CLOUD COMPUTING

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Abstract— *Latest trend in green computing and cloud computing require efficiency in consolidating virtual machine without degrading quality of service. This study, focus on minimizing the migration of Virtual Machine to produce lowest power consumption. To achieve this objective, a new algorithm is used to calculate the fly on the Lower and Upper Threshold Limit using Statistical Process Control theory. This new algorithm is called Dynamics Threshold Optimize System. Three sigma theories are applied in order to get the desire range for the threshold limit. This study applies Optimize Warm Threshold Limit as a secondary algorithm to optimize the Lower Threshold Limit. This technique is used to determine the mod value from a range of mean value and existing Lower Threshold Limit. If the mod value is higher than the existing Lower Threshold Limit then it will replace the existing Lower Threshold Limit.*
Index Terms – cloud computing, green computing, Dynamics Resource Allocation, Statistical Process Control, Three Sigma.

I. Introduction

Nowadays, cloud is a famous metaphor among internet user worldwide. Cloud Computing allows outsourcing of IT needs like software, storage and computational via large internet. The service oriented computing somehow ease the management and administrator process when dealing with software upgrade and bug fix [1]. As for the small IT companies, they produce a fast application development and test without the need to invest on architecture. Since the demand of Cloud application increase drastically, it is foreseen that plenty of Cloud provider will appear on continuous growth via internet. Thus by deployment of plenty of new data center will put more computers, and this will somehow increase energy consumption and create negative pressure on environment. Recent research showed that by running on a single 300-watt server in a year will cost about \$338 and emit 1,300 kg CO_2 inside our atmosphere [2]. Based on the previous study, the main issue on data center is on high energy consumption where it has raised by 56% within 5 years from 2005 to 2010 and increase of global electricity use by 0.35% [3]. Recent studies showed that power consumption of data center in USA, was around 100 billion kWh in 2011 with a cost of \$7.4 billion. This power consumption contributed 0.5% of total electricity for the world [1]. Figure 1 show the increment of energy consumption by Data Center from 2000 to 2012. It shows an increment of 130% from 2000 to 2005, 75% from 2005 to 2010 and 16% from 2010 to 2012. According to McKinsey [4] the overall estimated energy bill in 2010 was \$11.5 billion and energy cost has doubled in every five years.

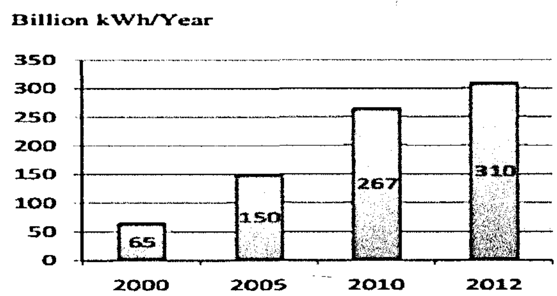

Figure 1: World Wide Data Center Energy Consumption. [1]

II. Problem Statement:

High energy can cause un-control carbon dioxide (CO_2) substance to the atmosphere which gives impact to greenhouse. Existing energy-efficient based resource allocation for various computing systems [5] are not suitable for Green Cloud Computing as it is not dynamic enough to cater the changes on demand in Cloud Computing. Resource provision mechanism which use policy based on heuristics is also unsuccessful when dealing with the appearance of conflicting goal especially when the client is in a dynamics environment [6]. Existing methods on dynamics resource provisioning and allocation algorithm, with different number of fixed thresholds for both Lower Control Limit and Upper Control Limit is only fit for statics environment [7]. Those techniques are also unable to reduce significant power consumption at Data Center in dynamics environment.

III. Objective:

The main objective of this study is to achieve green computing by targeting the number of Virtual Machine and Physical Machine migration that should be used as minimized as possible in order to achieve a low usage of power in the data center. In order to achieve this objective, an Intelligent Resource Management System (IRMS) is introduced, which also could contribute some other values such as:

- New algorithm is designed to calculate Upper Control Limit (UCL) and Lower Control Limit (LCL) in real time, which make it suitable for both static and dynamics environment. Thus, Statistical Process Control method is used in order to implement the new algorithm.

- A sub system is created, where the emphasized is to move all under load VM to the available resources across all sites, and shut off all the idle VM to achieve Green Computing.

IV. Hypotheses:

Proposed technique in this study is expected to perform better due to reasons listed below:

- Threshold values for Upper Control Limit and Lower Control Limit are not fixed. Those threshold values will be change on the fly by proposed algorithm using Statistical Process Control method. Those changeable threshold values are suitable for all environments either static or dynamics.
- By using a basic statistical method of mode formula, the second proposed algorithm will amend Lower Control Limit for the purpose of moving a significant idle VM to other VMs and shut off those VM.

V. Related work:

Currently, many researchers have experimented several approaches to achieve Green Computing, namely as [8] Product longevity, Algorithm efficiency, Resource allocation, Virtualization and Power Management. The obstacles that need to be addressed by researchers is not just to satisfy QoS requirement on Service Level Agreement (SLA) but also to reduce the energy used at Data Center side.

Figure 2 show that, there are two main components inside Green Cloud Framework i.e., Virtual Machine Control and Data Center Design. This research carried out a detailed study on Virtual Machine Control. Virtual Machine Control itself consists of scheduling and management. This study is carried out to confront the issue on management side, where the emphasis is more on data migration.

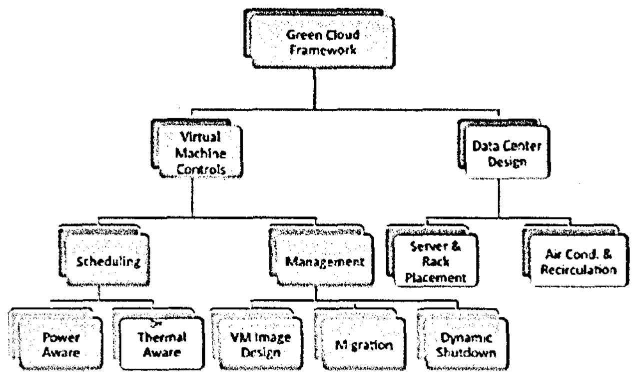

Figure 2: Green Cloud Framework

Several techniques used to accomplish the target of Green Computing are discussed below:

Yamini [8] had explored on green scheduling algorithm using the algorithms called ECTC (Energy Consolidation and Task Consolidation) and MaxUtil (Maximum Utilization). MaxUtil algorithm is used for task consolidation based on resource utilization, while ECTC algorithm stressed on computing energy consumption on current task. The used concepts are;

- ❖ Determination of profiling data for optimal points.
- ❖ The use Euclidean distance theory from existing allocation with the optimal points.

MaxUtil algorithm is more energy-efficient as compared to ECTC algorithm, as it could minimize the used resources.

Dalapati et al [1] studied on Green Scheduling Algorithm by optimizing server power consumption using a method of neutral network predictor. In this study, they applied it only for high performance cluster computing. The cluster jobs are executed by providing virtual machine dynamically and used vital checking on existence of idle machine and put them to sleep. They discovered that a proper load balancing scheduling on virtual machine and putting idle machine to sleep mode can create a green cloud solution.

Sato et al [2] evaluated a Green Schedule Algorithm by predicting to turns off unused servers and that can minimize the energy used. They point out that the power consumption seems to be linear with CPU utilization. Increment of 10% in CPU utilization will increase Power Consumption approximately 6.3% (quad-core) and 3% (dual-core) respectively. Another room of improvement had been discovered by them where it seems that power consumes during idle states are about 62% (quod-core machine) and 78% (dual-core machine). This is where the propose algorithm will improve on this by turning off all VM which are in idle.

Geronimo et al [9] had considered hybrid strategies for allocation and provisioning. The main purpose was to optimize the usage of cloud without decreasing the availability. This hybrid strategy was based on distribution system management model which consists of the base strategies, operation principle, test and present the result. Cloud simulation tool called Cloud Sim was used to simulate a University Data Center environment. Two distribution models were used from a real distribution and the other distribution was used from mathematical oscillatory model. As for the outcome, 52% power consumption reduction was seen over Spare Resource strategy on the hybrid provisioning in green clouds. On the contrary, model used in this study is more suitable for all the types of clouds computing which are private, public and also hybrid.

Wu et al [10] presented a Green Energy-Efficient schea duling Algorithm by using priority Job Scheduling concept. In order to control the voltage supply and frequency, DVFS technique was applied. The outcome was that energy consumption is reduced drastically with the impact on slightly lost performance of the system. Proposed method in this is more on calculating threshold by statistical approach.

Lee et al [11] studied on a Dynamics Energy Saving Mechanism in Cloud Computing by using Dynamics Voltage Frequency Scaling (DVFS) technique and it works by monitoring CPU Utilization. The proposed system can be categorized into three parts which are CPU Utilization monitoring, DVFS adjustment and real-time migration. The simple concept was used, where when CPU Utilization is low, the power will be adjust toward low and vice-versa when CPU Utilization is high. This concept is seems to be working excellent in case of heavy workload. Here the fix thresholds were used, and vice-versa with our propose method where changeable threshold will be used.

Hasan et al [3] and Suchithra et al [12] proposed and evaluated a heuristics based resource allocation for VM selection and VM allocation approach. In their heuristic definition, several techniques had been implemented which are;

- Detecting on over loading.
  They introduce an alternative method to MAD which are more efficient and not imbalance with Symmetric distribution. A fix upper threshold is define with a changeable safety parameter was introduced.
- VM selection criteria
  In detecting over loading section, Migration time and CPU utilization are two main factors when deciding which VM to be migrated. The amount of memory used divide by the bandwidth will give an estimator of migration time.
- VM Placement
  The best fit decreasing algorithm will take place first then VM Placement algorithm will resume its task. Two factors that will be considered during VM Placement are CPU utilization and power consumption.
- Detection of under loading.
  Simple approach was used by taking a less CPU utilization and compares it with other VM. Then move the VMs to other hosts until it get overloaded or CPU utilization of the origin VM become less than 5%, and later we shut down the origin host. 70% of power consumer by running server come from idle server [13].

These propose techniques reduce power consumption up to 36.37%, 15% on improve at SLA and increase profit to cloud providers by 46.25%. Our proposed algorithm will be performed better as to the thresholds use will be changed on the fly to suit the demand environment.

Xiao et al [14] studied on allocating data center via virtualization technology based on the users demand. Two different techniques used are;

- The concept of "skewness" for the purpose of addressing unevenness in the multi-dimensional resources utilization.
- Heuristic method was introduced to prevent over load in the system.

They predicted by minimizing the "skewness" it can improve the overall utilization of server. On the other hand, our propose sub-system which is Optimizer Warm Threshold Limit will eliminate the under load VM and turn it off.

Buyya et al [7] developed a dynamics resource provisioning and allocation algorithm which considers the synergy between various data center infrastructure. There are two main problems to address here which are;

- Admission on new request for VM provisioning and placing the VM on hosts.
- Optimizing current allocation of VMs

They proposed solution to overcome the concern issues to use modification Best Fit Diagram (MBFD) algorithm and four heuristic methods. MBFD work by sorting all VMs in decreasing order of existing utilization and then allocate every VMs to the host that will provide least increment on power consumption after the allocation take place. Ideal of first heuristic is actually Single Threshold (ST) where setting upper utilization for host and do placing of VMs. Total utilization of CPU must be monitored during placing VMs so that it won't exceed upper threshold. As for other three heuristic methods, basically they setup specific regions which have one lower threshold and one upper threshold. When CPU Utilization is outside this region where it can be either on lower or upper side, below action will take place:

- CPU Utilization below or equal as Lower Threshold: All the VMs will be moved from this host and the host will be shut off, thus this will reduce energy consumption. CPU Utilization bigger or equal as Upper Threshold: VMs will be move to other host until CPU utilization less than Upper Threshold; this will prevent potential of SLA violation.

In order to fulfill those three heuristic methods, they did come out with 3 different policies to cope with that and they are:

- ❖ Minimization of Migration (MM)
- ❖ Highest Potential Growth (HPG)
- ❖ Random Choice (RC)

In summary, Single Threshold (ST) at 60% will give power consumption at 1.5kWh while region of 50% to 90% will give power consumption at 1.14kWh. Their model won't be suitable for moving window of demand load from user side. As for my proposed model, it will suitable for those unpredictable demands from user due to the proposal algorithm will change the thresholds limit on the fly.

Hasan el al [15] have investigate on heuristic based resource allocation where it more focus for VM selection and VM allocation. The target is to minimize the energy consumption and operating cost, at the same time meeting the client-level SLA. They discover that number of VM migration is directly proportional with Power Consumption.

Patil et al [16] proposed energy aware computing algorithm called Double Threshold Energy Aware Load Balancing, using a fix threshold for lower 25% and upper 75% respectively. They discovered DT-PALB is performed better in term of Power Consumption compare to original PALB which is a single threshold.

Song et al [17] proposed a general Framework for task selection and allocation, where at first they will fix three threshold point which are upper limit , middle limit and lower limit.

Galloway et al [18] studied on Power Aware Load Balancing algorithm. They used a fix range of threshold for Upper and Lower Limit, and the range used was 25% and 75%. In their case when CPU Utilization above 75%, they will instantiate new Virtual Machine, and in case of CPU Utilization is lower 25%, it will shut off the Virtual Machine.

Sahu et al [19] studied on the use of Dynamics Compare and Balance algorithm for the purpose of optimization of Cloud Server. Here they obtained the value of Threshold limit dynamically by calculating total capacity of server time some special coefficient. They concluded that as for Upper Threshold limit, number of cloudlet is directly proportional relation with number of migration, and as for Lower Threshold limit, number of cloudlet is directly proportional with Power Consumption.

VI. Methodology:

Design Solution.

Figure 3 is the diagram for the Main System. It shows that there are two main elements which are Intelligent Resource Management System (Graphic User Interface Application) and Intelligent VM Management. Intelligent Resource Management System (IRMS) will get the input from the Random Generator Algorithm. The range of data for Random Generator will be set from 1 to 100. Later the input on CPU utilization enter via IRMS will be process at Intelligent VM Management. Intelligent VM Management is consists of three layer of processing which are Dynamics Threshold Optimize System, VM Placement and Power Management. Figure 4 shows in detail how Intelligent VM Management represents in processing flow.

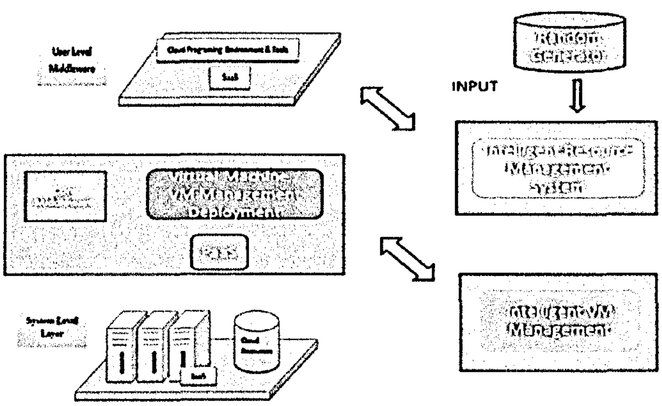

Figure 3: Overview Main System

Intelligent VM Management System

This study is focused to explore on Middleware (PaaS) level which involves Virtual Machine part. To be specific, this study concerns on how power consumption can be reduced by optimizing the migration of Virtual Machine (VM's). In order to achieve that target, a detail study on how a dynamics specification of Overload and under load can influence power consumption level is investigated in detail. In the case of unpredictable workload (Dynamics), the usage of fixed value (static Method) of the utilization threshold is not suitable solution to go with [1] [4]. A static approach by using different value for lower and upper threshold had been carried out, and it is found the different power consumption value in threshold setting [13]. Thus, this Dynamics Threshold Optimize System (DTOS) will overcome the current vital issue. Figure 4, shows that Intelligent VM Management is consists of three different components which are Dynamics Threshold Optimize System (DTOS), VM Placement and Power Management.

Dynamics Threshold Optimize System

Initially, the system uses a static approach of setting up Hot Threshold Limit (Upper Control Limit) and Warm Threshold Limit (Lower Control Limit). The first 25 is set as Warm Threshold Limit and 85 as Hot Threshold Limit. After sampling of 32 samples, Dynamics Threshold Limit will be executed by calculating a new HTL and WTL using Statistical Process Control Method (SPC).

SPC method calculates mean value for 32 samples of data. According to Central Limit Theorem, when the number of samples is large enough, the distribution will be normal. General rule recommends a sample of more than 30 [20] to prove SPC worked perfectly in several processes such as in Software Development, monitoring and control [21-23]. In order to get a distribution of 81.1%, we use 3σ as a formula. Where, σ is a standard deviation.

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}, \quad \text{where } \mu = \frac{1}{N}\sum_{i=1}^{N} x_i.$$

[24]

$$\bar{X} = \frac{\sum X}{n}$$

[6]

Hot Threshold Limit (HTL):

X + 1.5*σ

Warm Threshold Limit (WTL):

X – 1.5*σ

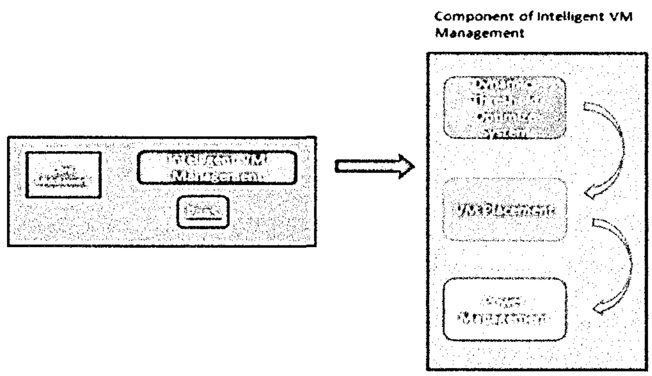

Figure 4: Intelligent VM Management System Diagram.

Optimize Warm Threshold Limit

Inside the Dynamics Threshold Optimize Limit, there is another sub system called Optimize Warm Threshold Limit (OWTL). Based on previous studies [2], the delta of power consumption for Linux AMD Quad-Core 2.2Hz, at 25% CPU compare with 85% is about 50 Watts [5]. Thus there is a huge opportunity to optimize the Warm Threshold Limit to achieve lower power consumption at Data Center, by using Mod calculation method then compare Mod value with existing Warm Threshold Limit. If a value from Mod calculation is greater than existing Warm Threshold Limit, then a value from Mod calculation become a new Warm Threshold Limit.

And if it is vice-versa, existing Warm Threshold will remain as it is.

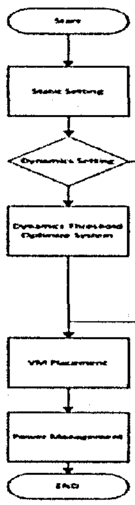

Figure 5: Flow Chart of Intelligent VM Management

VM Placement

Figure 5 shows that VM Placement will take place after DTOS and OWTL. When Upper Control Limit and Lower Control Limit are known then it will execute VM Placement. First, the system will check any occurrence on overload section and if there is any occurrence there, it will be moved to other VM which is not been fully utilized yet.

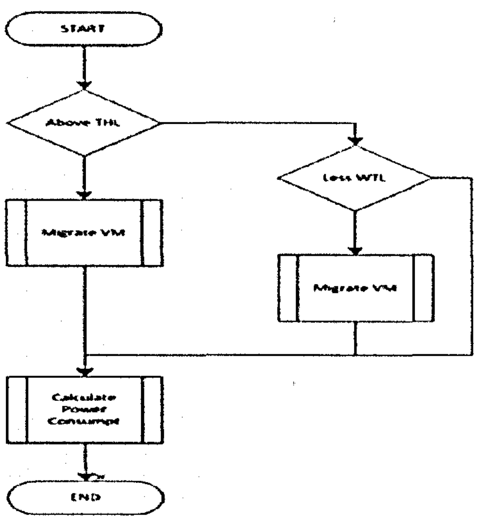

Figure 6: Flow Chart of VM Placement

Second, the system will check the under load section. If found any occurrence there, those related task will be moved to other VM and shut down the involved VM to reduce the power consumption. This study uses the existing Allocation Policy which is Local Regression (LR), and Selection Policy which is Minimum Migration Time (MMT) with a parameter number is 1.2. Ghafari et al [25] discovered that combination of Local Regression and Minimum Migration Time with 1.2 setting can produce Lowest Power Consumption compare with IQR-MMT-1.5, MAD-MMT-2.5 and BEE-MMT.

Data Collection Method

This study used the same data input for CPU utilization using the Random Generator Mechanism to create some random CPU Utilization number. The data is tested using several hypotheses model as listed in Figure 7. The data of CPU Utilization inside the distribution margin in between Upper Control Limit and Lower Control Limit will be calculated and compare with all the test condition.

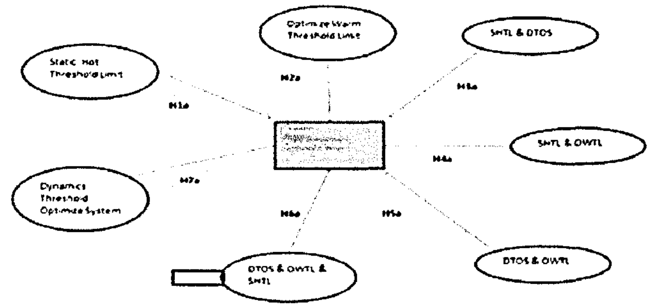

Figure 7: Hypothesized Models

Setting for cloud Environment

Initial setting which is listed in Table 1 represent Virtual Machine and Table 2 for Data Center are hardcoded inside the program. Besides that the number of hosts is set to 20 and cloudlet number is set to 10.

Table 1: Setting for Virtual Machine (VM)

No	Items	Setting
1	Million Instruction Per Second (MIPS)	250, 500, 750, 1000
2	Number of CPU	1
3	RAM	128 (MB)
4	Bandwidth	2500
5	Image Size	2500 (MB)
6	Name	XEN

Table 2: Setting for Data Center

No	Items	Setting
1	System Architecture	X86
2	Operating System	Linux
3	Name	XEN
4	Million Instruction Per Second (MIPS)	1000, 2000, 3000
5	RAM	10G
6	Bandwidth	100000
7	Storage	1T
8	Max Power	250W

VM Management Setting

In the VM management setting there are two main steps (see Table 3). They are VM selection action and VM allocation action. This study selects Local Regression (LR) Policy for VM allocation action and Minimum Migration Time (MMT) policy as VM selection action.

Table 3: VM Placement Setting

No	Items	Setting
1	Allocation Policy Name	Local Regression (LR)
2	Selection Policy Name	Minimum Migration Time (MMT)
3	Parameter Number	1.2

VII. Data Analysis

Single Mode Analysis

From the Table 4 it can be seen that the mean of Migration for SHTL and DTOS is the same which is 8, meanwhile as for OWTL number of migration is 19. It can be concluded that migration for OWTL is double from migration of SHTL and DTOS. The differences of mean Power between DTOS and SHTL is around -0.00052, which is very small. Mean Power for OWTL is around 0.1474, and it is more than double if compare with the one from SHTL and DTOS. As for the Standard Deviation value, DTOS and SHTL have nearly same value where the delta is very small, around 0.00030. The value of Standard Deviation for OWTL is doubled than value of DTOS and SHTL, which is 0.02396. It can be summarized that Mean Power, Standard Deviation and Mean Migration values for OWTL is two times more than the value of SHTL and DTOS (refer to Table 4).

Table 4: Output of Power and Migration for Single Mode

No	Case Mode	R-Square (%)	Mean Min Limit	Mean Max Limit	Mean Power (KWh)	Standard Deviation	Mean Migration
1	SHTL	6.2	25	85	0.06320	0.01162	8
2	DTOS	11.2	4	92.5	0.06268	0.01132	8
3	OWTL	99.6	19.5	0	0.1474	0.02396	19

The range of Minimum and Maximum Limit indicated in Table 4 shows that, the limit range for DTOS is from 4 to 92.5 compares to SHTL which is from 25 to 85. The coverage range for Case of DTOS is about 88.5% while SHTL is only 60%. By executing OWTL mode, the Minimum Limit is increased from 4 to 19.5, this is an increment of 19.29%. Previous study proved that range threshold of 30% to 90 %, the Power Consumption will be around 1.29kWh and single threshold of 50%, Power Consumption is 2.03kWh, single threshold of 60% Power Consumption is 1.50kWh [26]. The threshold value in this study ranges from 4% to 92.5% and the Power Consumption is 0.06268kWh. It can be concluded that the bigger the range of threshold limit, the Power Consumption will be smaller. Thus this study achieved its main objective to achieve Green Cloud Computing.

Combination Mode Analysis

Table 5 indicates that the lowest Mean of Power is 0.06334 for SHTL and DTOS, and the highest Mean of Power is 0.1048 for SHTL and OWTL. The Migration for case of SHTL and DTOS is 8, while for case SHTL and OWTL is 11. It can be concluded that there is a direct relation between Mean Power and Migration [26].

Table 5: Output of Power and Migration for Combination Mode

No	Case Mode	R-Square (%)	Mean Min Limit	Mean Max Limit	Mean Power (KWh)	Standard Deviation	Mean Migration
1	SHTL & DTOS	10.3	23.5	85	0.06334	0.01105	8
2	SHTL & OWTL	86.1	25	42.5	0.1048	0.04633	9
3	DTOS & OWTL	93.5	10	34.5	0.1047	0.04655	11
4	DTOS & SHTL & OWTL	94.6	19	85	0.09231	0.4477	9

Table 5 indicates that the biggest range is for all cases (SHTL, DTOS and OWTL). The range is from 19 to 85 (range of 66) and the smallest range is from 25 to 42.5 (range of 17) which is under the case of SHTL and OWTL. Even though all cases (SHTL, DTOS and OWTL) have a big coverage of 66%, but it did not produced a lowest Mean Power or Number of Migration. However compare to previous study [26], their test case of MM (Minimum Migration) is 30% – 90%, the Power Consumption obtained is 1.27kWh and in our case of All (SHTL, DTOS and OWTL) where the range is 19% – 85%, the Power Consumption is 0.09231kWh. This algorithm of all cases (SHTL, DTOS and OWTL) performed 27% better than MM 30% – 90%.

VIII. Conclusions

The purpose of this study is to achieve a Green Cloud Computing by applying Statistical Process Control technique to change the Lower Control Limit and Upper Control Limit in the fly, using three Sigma calculation methods. The target which needs to be achieved here is to have a lower Power Consumption and a minimum number of Virtual Machine Migration. Table 6 shows the overall data of Power (KWh) and Number of Migration for all cases. It can be concluded that DTOS mode is producing a smallest Power and a minimum number of migration required. DTOS performance is 1% better compared to SHTL, with the number of migration is almost the same. As compared to OWTL, the performance of DTOS is lower, about 57% in term of Power and also Number of Migration. Figure 8 and Figure 9 show the overall data for Power Consumption and Number of Migration. From Table 5, it can be concluded that the biggest coverage is DTOS mode where the range is about 88.5% and the smallest coverage is SHTL and OWTL mode with the range of 17.5%. It shows that DTOS with a range of 88.5% is performing 120% better than MM with a range of 30% – 90%, and 60% in Power Consumption [26]. In can be concluded that, number of Migration have direct proportional relation with Power (refer to Figure 10 where this data is consists of for seven test cases).

Thesis Contribution

Finding from this study contributes to the following:

- The API, called intelligent Virtual Machine Management has been designed and it interfaced with existing library of Cloud Simulation. Those API use Neat Bean as run time environment.
- Statistical Process Control technique has been used in the calculation of Lower Control Limit and Upper Control

Limit, and used three sigma concepts in the distribution of coverage limit. Using this method for case of DTOS, the range of coverage is about 88.5% and 19.5% for case of OWTL.

- The major finding in this study is that Power Consumption has a direct proportion with the number of Migration. This finding validates [27] the previous study. Figure 12 shows the relationship between Power Consumption and Number of Migration.

Table 6: Output of Power and Migration for All Test Cases

No	Items	Mean Min Limit	Mean Max Limit	R-Square (%)	Mean Power(KWh)	Standard Deviation	Mean Number of Migration
1	DTOS	4	92.5	7.4	0.06268	0.01132	8
2	SHTL	25	85	6.2	0.06320	0.01162	8
3	OWTL	19.5	0	99.6	0.1474	0.02396	19
4	DTOS & SHTL	23.5	85	10.7	0.06334	0.01105	8
5	DTOS & OWTL	10	34.5	93.5	0.1047	0.04655	11
6	SHTL & OWTL	25	42.5	86.1	0.1048	0.04633	9
7	SHTL & DTOS & OWTL	19	85	94.6	0.09231	0.4477	9

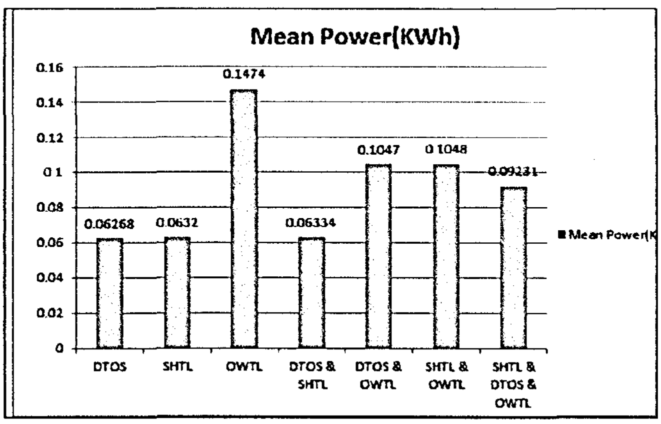

Figure 8: Overall Power Consumption for all test cases

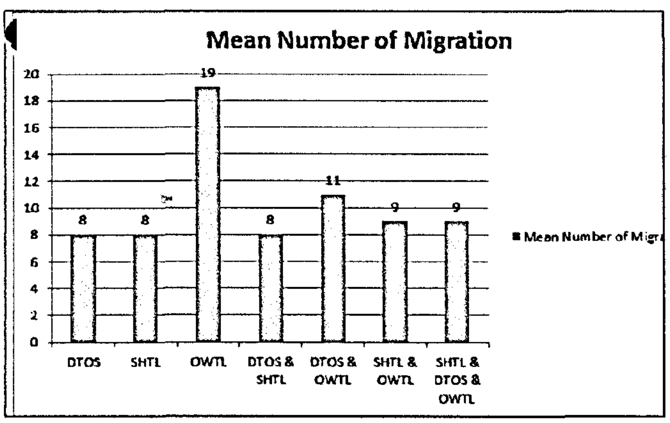

Figure 9: Number of Migration for all test cases

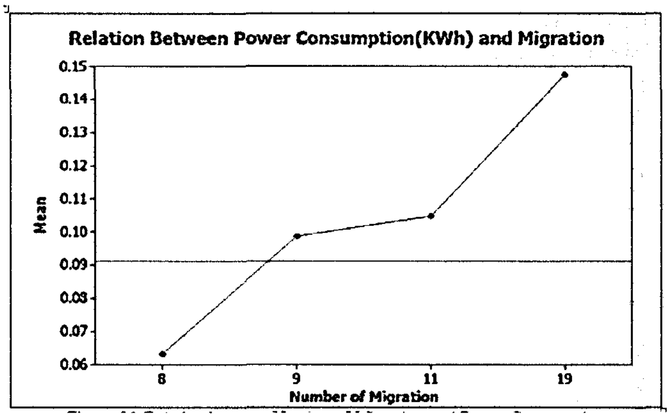

Figure 10: Relation between Number of Migration and Power Consumption

Future Scope

In this study, the method used in Virtual Machine Placement is Local Regression (LR). There is an opportunity to use more methods in order to obtain more significant result. They methods that can be used are:

- Inter Quartile Range (IQR)
- Median Absolute Deviation (MAD)
- Local Regression Robust (LRR)
- Static Threshold (THR)
- Dynamics Voltage Frequency Scaling (DVFS)

As for Virtual Selection, this study used Minimum Migration Time method. There are other options available to further investigate Virtual Selection. They are:

- Random Selection (RS)
- Minimum Utilization (MU)
  Maximum Correlation (MC)

Other potential element which can be re-visited is the optimization. Sigma Concept will give the best reduction in Power Consumption. Future study can also combine two different algorithms which are DTOS and OWTL into new algorithm where the aim here is to optimize the range of threshold and find out the outcome for Power Consumption and Number of Migration for VM.

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