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Multiple Regression Particle Swarm Optimization for Host Overload and Under-Load Detection

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Abstract:
Detection of overloaded and under-loaded Host approaches in cloud computing play a vital role. Most of the recent studies use only one resource called CPU to determine the host's load. In this paper, we propose anaccurate prediction model called Multiple Regression particle swarm optimization (MR-PSO) to detect resource utilization. MR-PSO uses two factors (a) CPU utilization and (b) memory utilization. This model Decreases energy consumption by enhancing the usage of the resources in data centers. The prediction model of the host load based on the Multiple Regression (MR) concept. Particle swarm optimization (PSO) algorithm is presented to choose the higher and lower threshold borders for host utilization. Simulation by using the CloudSim tool show that MR-PSO decrease the Energy consumption by 7.61% and ESV by 1.5% lowest than the previous studies when we use the same number of hosts, Virtual machines and tasks.

***Keywords:** Multiple Regression, Particle swarm optimization,host overload, host Under-load, CPU utilization, memory utilization,VM consolidation.*

1. Introduction

Cloud Computing is virtualization from the perspective of a cloud provider which means storing Multiple virtual machines (VM) in one host to allow better utilization of the host's resources. Thousands of hosts connected together are called the data center. Datacenter consumes high energy. High energy consumption cause increased emissions of carbon dioxide [1],[2]. Explanations behind these issues is the wastefulness in utilizing resources [3]. One of the fundamental concepts to solve this problem is by VM consolidations [4]. There are many ways to know the utilization of resources of the physical machine (PM) statically based on a fixed value of CPU utilization, Adaptive based on historical data collected about VM, and Regression methods based on future prediction of resource load [5]. Most recent studies depend on just a single parameter, for example, CPU usage to decide the VM load. Live migration of VM is used to optimize the utilization of the resources in the PM [6] by moving all the VMs or selected VM to a limited number of active PMs and switch off unused ones[7],[8],[9].

This paper aims to develop an efficient VM consolidation approach. In this approach, the multiple regression and particle swarm optimization algorithm [10],[11] is presented to check whether the host is under-loaded or overloaded. First, it calculates the resource utilization of CPU and memory for each VM. Then the multiple regression concepts are applied to predict the host utilization from the VMs utilization. Finally, the particle swarm optimization is introduced to identify the overload, normal or under-load host status. In contrast to existing techniques, MR-PSO is dynamically changing the usage of available resources and forecast the upcoming PM state accurately. This approach in addition to energy conservation it avoids the SLA violations of the host in cloud data centers.

The rest of the paper is organized as follows. In Section 2 a short discussion of the related works is provided, followed by the MR-PSO algorithm in Section 3, In section 4 the experimental results are reported, finally, we conclude this paper in section 5.

2. Related works

VM consolidation is an inclining research point and numerous researches have been centered around improving the presentation of VM consolidation procedure.

Beloglazovet al [4] figure and investigation the VM's historical data of CPU utilization to determine an upper thresholdfor detecting overloaded host that include two strategies (MAD) and IQR. The main issue in this way is a poor prediction of overloaded host. The subsequent way, it estimates the future utilization of CPU utilization for detecting overloaded host . There are two ways to calculate it, LR and LRR.It achieve better predicting of host overload but has more complexity.

Similarly, Monilet al.[12] presented another technique called MMSD. This technique employs the median, in addition, to mean and standard deviation to determine the host load. Host consider as overloaded if the utilization of the host more than 90% of host resources and underloaded if the utilization of the host less than 10%. However, in this research it considers only the CPU to calculate the utilization and fix value of thresholds.

AmanyAbdelsameaet al. [13] developed a VM consolidation model that uses the RAM, CPU,and network bandwidth. This model provided two algorithms called (MRHOD) and (HLRHOD) that improve the QoS and reduced energy consumption . Nevertheless, it uses a regression formula to normalize the predicted utilization with a fixed trigger point which could reduce the effective performance.

Minarolliet al.[14] implemented Mean, Median and Standard deviation based Overload Detection(MMSD) algorithm based on the summation of VMS utilization, it gives the host utilization depend on a standard deviation that makes long-term predictions of resource demands, predicting seven-time intervals ahead into the future. However, it uses CPU utilization only to detect if the host overloaded or under-loaded.

Markov et al. [15] gauge another model to compute the host's use dependent on current CPU use and future CPU usage. CPU thresholds is allocated based on statistical analysis of information gathered during the lifetime of VMs called (FOMCHSD) or dynamically based on a dynamic utilization threshold called (MadMCHD).After the CPU utilization is determined it contrasted with the lower and the upper threshold edge to decide the present host status. They divided the host statusinto three groups overload and under-load, and normal load. However, this research considers only CPU utilization to calculate resource utilization.

LIANPENG LI et al. [16] in his methodologyimplemented Robust Simple Linear Regression (RobustSLR) prediction model to predict CPU utilization by adding eight errors to the prediction to minimize SLA violation and power consumption. However, it uses only one parameter called the CPU to estimate the

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utilization and it needs more improvement to reduce power consumption and SLAV.

Chao Chen et al.[17] his strategy has concentrated on improving ODA which set forward another overload detection algorithm to accomplish better trade-off between energy and SLA violation . However the overload detection algorithm is for the most part dependent on VM‘s CPU history utilization to dedect the over use host‘s resources.

Moghaddamet al. [18] developed ML forecast model for each separate VMs to identify over and under-utilized hosts. The model focus on CPU resource to detect an over-utilized host. it decrease energy consumption and SLAVs. However, the ML forecast model considers only the CPU utilization to detect an over-utilized host.

Mohiuddin et al. [19] proposed an accurate prediction model for each individual VMs to predict future over-utilized hosts.. The algorithms significantly reduce energy consumption and SLAVs . but It only focus on CPU resource.

It can be noted from the literature that most VM consolidation models just use the CPU utilization to detect the host load. These models are easier to measure but the disadvantage is the efficacious estimation of load conditions. These issues are recognized as the motivations for creating multiple regression Particle Swarm Optimization model solutions to detect host load.

3.Multiple Regression Particle Swarm Optimization Algorithm

Dynamic VM consolidation involves in detect the host load by using the MR and PSO Algorithm in our model. In the event that the host is overloaded, the subsequent stage is reallocated[20] VM from an overloaded host to ordinary load .The emphasis test is continuous, If the chose host is as yet over-load, the following VM for migration list will be chosen, Repeat the procedure until the host enters a state where it isn't over-load.Minimum migration time is the most common model used for selection VMs and it's used in our model. If the host is under-loaded, the next step is to move all VMs to other hosts if available. The suggested MR-PSO algorithm achieves an over-utilization detection host in two phases. Multiple regressionsare an extension of linear simple linear regressionimplemented to predict the host's expected usage in the first phase. Then the PSO algorithm determines the higher and lower thresholds for expected use in the second phase. The host load states based on CPU and RAM resources are predictable using the multiple regression model. It can be showedas

$$Y = \frac{w_1}{1-CPU} \times \frac{w_2}{1-RAM} \quad (1)$$

Where $w_i$represents the weight of CPU and RAM whose weight within the range of [0,1].$CPU$is thePM's CPU utilization and $RAM$is thePM's memory utilization. By computing the$Y$values(dependent variable), the regression coefficients can predictthe future utilization of the host based on the two independent variables CPU and RAM. The predict utilization value should be put up by higher and lower threshold values that are setdynamically using the PSO algorithm.

Multiple regression model contains twoindependent variablesx_1, x_2that present the CPU (x_1)and RAM (x_2)utilization.

$$y = b_0 + b_1x_1 + b_2x_2 \quad (2)$$

$y$is the dependent variable. $x_1, x_2$are the independent variables. $b_x$is regression coefficients which are part results of y.

The Minimization of this equation in terms of Ordinary Least Square (OLS) standard can offerthe regression coefficients.

$$b_0 = \bar{y} - b_1\overline{x_1} - b_2\overline{x_2} \quad (3)$$

$$b_1 = \frac{(\sum x_2^2)(\sum x_1 y) - (\sum x_1 x_2)(\sum x_2 y)}{(\sum x_1^2)(\sum x_2^2) - (\sum x_1 x_2)^2} \quad (4)$$

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$$b_2 = \frac{(\sum x_1^2)(\sum x_2 y) - (\sum x_1 x_2)(\sum x_1 y)}{(\sum x_1^2)(\sum x_2^2) - (\sum x_1 x_2)^2} \quad (5)$$

The use of the CPU and the RAM of each PM is calculated as the average use of all VMs in the PM by the maximum use of the PM. Where $\bar{y}$ is the mean of y variables, $\overline{x_1}$ is the mean of CPU utilization and$\overline{x_2}$ is the mean of RAM utilization.The predicted equation of host utilization can be formed on the basis of the estimated regression coefficients as

$$predictedutilization = b_0 + (b_1 \times CPUutilization + b2 \times RAMutilization \quad (6)$$

By replacingthe CPU utilization values and RAM utilization valuesin the equation, the forecast Utilization of the PM is achieved.

by the social direct of animals. Itbegins by introducing the particles with the accessible arrangements. The wellness capacity of every molecule is then processed by predefined targets that select the best wellness esteem. The speed and position of each molecule are refreshed.The best an incentive for every molecule is then chosen and contrasted and pbest and gbest values. At long last, these means are rehashed until a halting condition is met.

$$\mathcal{X}i(t) = \mathcal{X}i(t-1) + \mathcal{V}i(t) \quad (7)$$

$$\mathcal{V}i(t) = \mathcal{W} * vi(t-1) + r1 * \mathcal{C}1(pbest - \mathcal{X}it-1 + r2 * \mathcal{C}2(gbest - \mathcal{X}it-1) \quad (8)$$

xi (t) is the present situation of particlei at emphasis t.xi (t-1) is the situation of the molecule I at cycle t-1.vi (t) is the speed of molecule I at emphasis t.pbestis the best position vector for emphasis to the individual I at the moment.gbestis the situation of the best molecule in thecurrent population.wis the latency weight with go [0, 1].r1, r2 are the irregular numbers with extend [0, 1] .c1, c2 are the increasing speed coefficients with run [0, 1].

In every cycle, there are two best qualities for every molecule. One is the pbest, which is the best for every molecule in the swarm, and afterward the best of all the pbest values is chosen as gbest for all particles.

$$pbest\ (\mathrm{i}, \mathrm{t}) = \min(\mathrm{f(pi)}) \quad (9)$$

$$gbest(\mathrm{t}) = \min(\mathrm{pbest(I, t)}) \quad (10)$$

i is the list of particle.t is the emphasis number .pbest (I, t) is the best an incentive for molecule I in cycle t.f (pi) is estimation of wellness capacity of molecule i.gbest (t) is the worldwide best for all particles in emphasis t.

In PSO, a few parameters are utilized to control the execution of the PSO calculation and improve the outcomes. These parameters incorporate the quantity of particles, the element of particles, the most extreme number of cycles, learning factors c1 and c2, dormancy weight (w), and arbitrary numbers r1 and r2.

By then the thresholds are settled for this foreseen Utilization subject to the PSO algorithm. The optimal lower threshold Th_{low} and upper threshold Th_{upper} limits are determined based on current host utilization (CPU andRAM).

As this step has been accomplished, the two threshold limits Th_{low} and Th_{upper} are returned. The procedure is rehashed by modifying and recalculating the fitness until the solutions are gotten.The thresholds are therefore collected and used to assess the state of the host overload. When the predicted utilization is between Th_{low} and Th_{upper}, the corresponding host is considered as normal loaded. Meanwhile, if the predicted utilization is less thanTh_{low}, the host is under-loaded and if the predicted utilization is greater

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thanTh_{upper}, the host is considered as overloaded.Algorithm 1 MR-PSO summarizes the wholeprocesses.

Algorithm 1: MR-PSO

Input: CPU and RAM utilization

Output: Decision on host status weather overloaded, under-loaded or normal

For each host in the host list do

For each VM do

Calculate the {CPU, RAM} utilization

$$Y \leftarrow \frac{w_1}{1-CPU} \times \frac{w_2}{1-RAM}$$

Apply OLS via Eq. (3) (4), (5);

Calculate the regression coefficients via Eq. (2);

Estimate the forecastusageof resources via Eq. (6)//Apply MR-PSO

Initialize PSO and design search space;

Iteration T=0;

Set particle as utilization values;

For each particle

Calculate host utilization in each iteration;

Estimate fitness values using Eq. (7)

Compare & determine pbest and gbest;

Rank utilization in descending order using CPU as priority

If no position = pbest or gbest

Produce new position using Eq. (8)

Else if

Update positions (9) (10);

T=T+1;

Return $Th_{low} \neq 0$ *and* $Th_{upper} \neq 1$;

End for

$If predicted utilization \geq Th_{upper}$,

Host is overloaded;

Else $If predicted utilization \leq Th_{low}$,

Host is under-loaded;

Else If

$Th_{low} > predicted utilization > Th_{upper}$,

Host is Normal loaded;

End if

End for

End for

4. Experimental results and discussion

CloudSim tool is used to evaluate the performance ofthe MR-PSO algorithm to detect the host load status. We have considered 150 physical nodes as servers and from 30 to 190 VMs. These servers are assigned with 1860MIPS (Million instructions per second) for the core. Network bandwidth is considered as 1GB/s and VMs are dual-core. Hosts of two types namely HP Proliant G4 (Intel Xeon 3040, 1.86 GHz, 2 cores, 120 GB RAM), and HP Proliant G5 (Intel Xeon 3075, 2.66 GHz, 2 cores, 80 GB RAM) are used. The host load is repeatedly calculated every 350 seconds.

The performance metrics areEnergy consumption, SLA, PDM, SLATAH, SLAV, and

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ESV at different workloadsgained for the proposed MR-PSO is displays in Table 1. The number of PM is set as 150 and the number of cloudlet (task) is set as 2500 while the number of VMs is varied from 30 to 190

Table.1. Performance metrics*(150 hosts & 2500 tasks)*

Parameter	**30**	**50**	**70**	**90**	**110**	**130**	**150**	**170**	**190**
Energy consumption (kWh)	12.5	44.8	54.4	76.8	74.832	94.64	115.168	123.248	142.099
SLA	0.00743	1.8672	1.87	24.7	77.744	68.77	59.664	52.4272	53.384
PDM	0.047	0.3728	0.27	3.5	10.749	8.05	6.9184	7.70448	7.01776
SLATAH	18.35	32.28	32.71	32.2	61.874	55	51.04	44.24	27.6512
SLAV	0.8625	12.034	8.83	112.7	665.084	442.75	353.115	340.8462	194.0495
ESV	10.78	539.12	472.60	8720.7	49768.29	41885.4	40667.6	42008.61	27574.28

Using the available resources efficiently to reduce energy consumption is the main objective of developing the proposed MR-PSO approach. The growth in the number of VMs generally increases energy consumption . It is additionally observed from Table 1 that when the quantity of hosts is set as 150 and the quantity of Tasks is set as 2500, the aftereffects of MR-PSO are very encouraging.The comparison of MR-PSO, with some of the current host load detection algorithms displays in Table 2.The performance of the MR-PSOalgorithm is compared with the currenthost load detection algorithms called LRR[5], LR[5] , MAD[5], IQR[5],THR[5] , HLRHOD[13], MRHOD[13], EWMAE[16] and MRMOSLO[21]. The parametersperformance metrics used forcomparison are energy consumption,SLATAH,SLA,SLAV,PDM,and ESV parameters.

Table.2. Performance comparison MR-PSO vs. other load detection algorithms

Algorithms	**Energy**	**SLA*(10^{-7})**	**PDM**	**SLATAH**	**SLAV(*10^{-5})**	**ESV(*10^{-3})**
THR [5]	41.81	0.03048	0.23	12.99	2.987	124.917
IQR [5]	36.4	0.06521	0.27	20.85	5.629	204.914
MAD [5]	37.84	0.04304	0.25	17.34	4.335	164.036
LRR [5]	19.7	0.00765	0.031	99.12	3.001	59.12
LR [5]	19.7	0.00765	0.031	99.12	3.001	59.12
EWMAE[16]	15.4	0.00536	0.01	27.3	3.1	12.3
HLRHOD[13]	13.53	0.00744	0.01	82.05	0.82	11.101
MRHOD[13]	13.48	0.0066	0.01	67.67	0.804	10.9406
MRMOSLO[21]	15.4	0.00757	0.087	20.0434	1.744	26.85
MRPSO	12.5	0.00743	0.047	18.35	0.86245	10.78

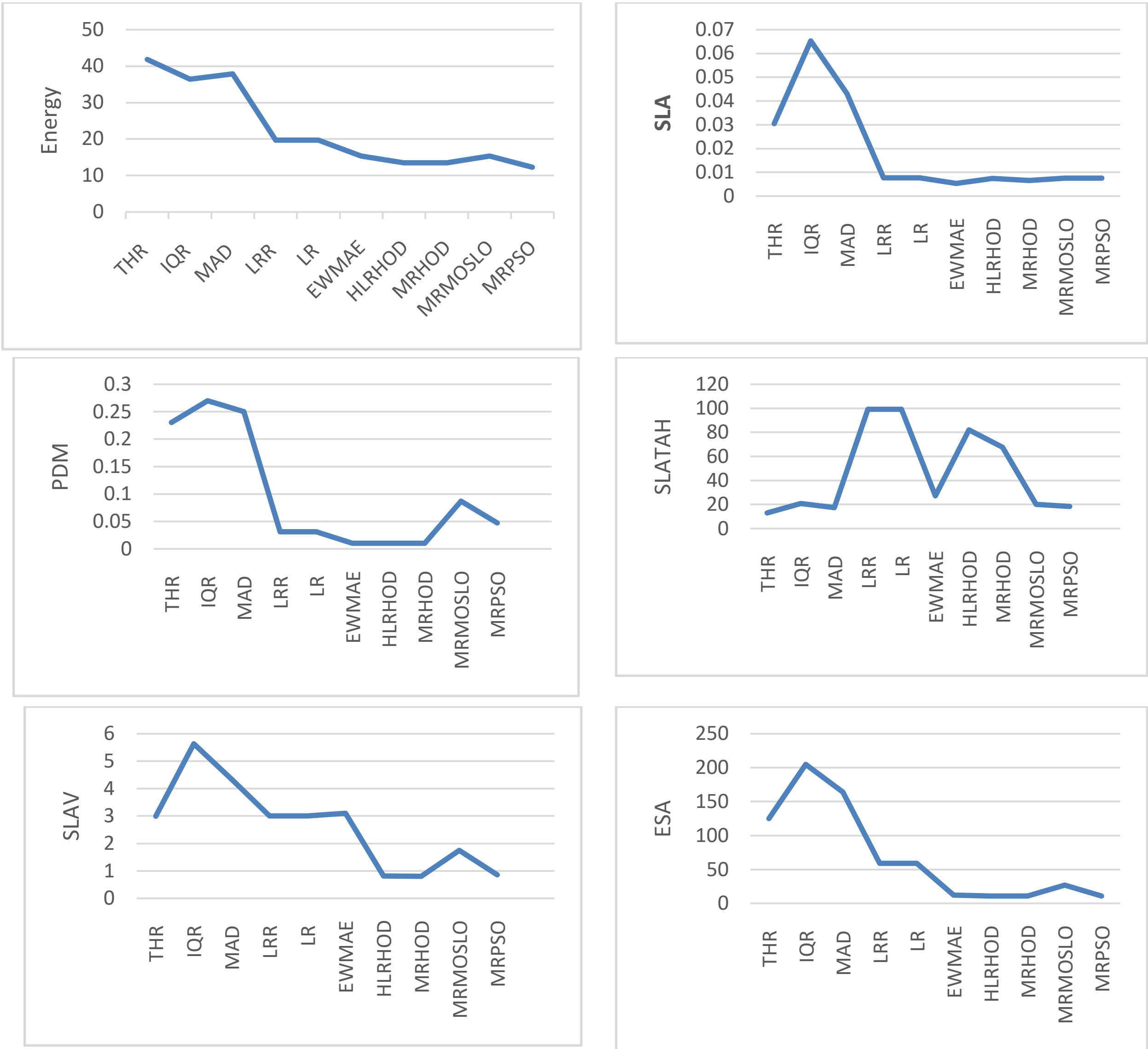

Figure 1.Comparison of Host load Detection Algorithms

The energy consumption (E) is the amount of power used. It is measured in watt or kilowatt-hours (kWh).The energy consumption of the proposed MR-PSO approach is 12.5 kWh which is the lowest of all other compared load detection algorithms.

Service Level Agreement (SLA) is acontract between customers andcloud service provider that can be firm by features as maximal response time or minimalthroughput. It can be measured as 100 dividedat any point by the percentage of the application performance. The SLA is higher than some of the current host load detection algorithms.

Performance Degradation due to Migrations (PDM) is the calculated performance degradation due to VM migrations.

$$\mathrm{PDM} = \frac{1}{M}\sum_{i=1}^{M}\frac{C_{di}}{C_{ri}} \qquad (9)$$

Where$M$ is the number of VMs,C_{di} is the estimated performance degradation of the VM i due to migrations,C_{ri} is the total CPU capacity.ThePDM almost the same value in the proposed MR-PSO approachwhen comparedto other algorithms.

SLA violation Time per Active Host (SLATAH) is the ratio of time when the PM stays overloaded.

$$\mathrm{SLATAH} = \frac{1}{N}\sum_{i=1}^{N}\frac{Toi}{Tai} \quad (10)$$

where N is the number of hosts, Toi is the total time when the host i has 100% utilization, Tai is the total time when the host i is an active state.SLATAH is 18.35 which is higherthanfew of the other compared algorithms.

SLAV is calculation of violations happened that affects the service running in the host. SLAV depend on PDM and SLATAH.

$$SLAV = SLATAH \times PDM \quad (11)$$

The SLAV is 0.86245 .

Energy and SLA Violations (ESV) is calculated as a result of Service level agreement violation (SLAV) and Total energy consumption (E) .

$$ESV = E \times SLAV \quad (12)$$

In the proposed MR-PSO approach the ESVis 10.78 which is lowest than all the other compared algorithms.From the simulation results and Figure 1, we have got the following conclusions: It is inferred that the proposed MR-PSOapproach has less power consumption and ESVthan all previous load deduction algorithms,there is no noteworthy difference with the PDM and SLAV.The SLA and SLATAH are negligibly higher than some of theprevious studies.

5. Conclusion

Different relapses Particle Swarm improvement (MR-PSO) algorithmfor recognizing the status of host load has been executed right now. To start with, the anticipated model figures the usage of the host by utilizing different relapses dependent on the CPU, and RAM uses. At that point, PSO decides the status of host load dependent on have use in various rounds. The acquired uses are arranged in plummeting request with the two wellness parameters CPU and RAM where CPU is given the higher need for arranging request. The largest and smallest fitness value of utilization is selected as the highest and lowest thresholds. Depending on these thresholds, the status of the host load classified as overloaded, under-loaded or normal load. Experiment results shown that the proposed MR-PSO algorithm improves VM consolidation For 150 hosts, 30 VMs and 2500 tasks, MR-PSO achieved the values of Energy is 12.5 kWh and ESV is 10.78 lowest than the previous methods. In future work, a new approach will be considered to enhance the performance in terms of SLA, SLATAH,SLAV, and PDM.

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