



A POWER EFFICIENT VIRTUAL MACHINE CONSOLIDATION FOR SAVING CARBON FOOTPRINT USING META HEURISTIC ALGORITHMS

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ABSTRACT

With the demand in internet mobile computing with the introduction of 3G/4G networks, there is a fast demand with the computing resources at the datacenter which is leading to excessive power consumption. The prevailing system is tough to produce an honest exchange between power and performance. In the proposed system a unique approach to consolidate multiple virtual machines in exceedingly cloud based distributed hosting surroundings. The system is tested with various meta-heuristic techniques like penguin search optimization algorithm (PeSOA), particle swarm optimization (PSO), and Memetic algorithm and provides the comparative results under it. This agrees to split VM sources along with applied programs, the amount of need in VMs is also decreased.

Keywords: Virtual machine, Consolidation, Cloud Computing, Green Computing

1.0 INTRODUCTION

The hasty growth in the Internet Technology and the rapid requirement of computational service over the internet is scaling the Datacenters over the world. Even though there is a significant reduction in the number of server base with the advancement in Virtualization, there is an increasing trend in the electricity usage of each server [1]. It is reported that about 1.1% to 1.5% of total electricity usage is from the global Datacenters [1].

The increasing trend in electricity usage and the carbon footprint due to the IT infrastructure and its supporting infrastructure like cooling, lighting, UPS power etc are major problems at the Datacenter. Dynamic consolidation of Virtual Machines and putting the idle nodes to sleep mode or switching off the machine will optimize the power usage to a greater extent. Power usage of Server hardware can be directly measured with various equipments, but measuring power usage of Virtual Machines are not directly possible because there is no devices for measuring Virtual Machine power. These Virtual Machines are just software implementation of actual hardware. There are many power metering methods as introduced in [2] [3] to measure the power of Virtual Machines which calculates the power as the sum of utilization of CPU, Memory and IO access. The capability of a Host machine or a Virtual Machine is represented in MIPS (Million Instructions Per Second) and the utilization of Virtual Machine and the power drawn can be identified through this [4].

[5] used Ant Colony Meta-Heuristic algorithm to migrate the virtual machines. This method monitors the current resource requirements and depending on the need, artificial ants consolidate the Virtual Machines. This uses a maximum threshold limit of 80% for the CPU utilization. [6] defines four major problems on Virtual Machine consolidation, when the host is overloaded, when the host is under loaded, Virtual Machine selection from a overloaded host and active Virtual Machine migration. This uses a forecast and management algorithm to decrease the energy usage, at the mean time maintaining the SLA violations. This uses a trained machine learning mechanism using the historical data to predict the future usage of Virtual Machines. [7] focused on host overload detection. Markov Chain is used to identify the mean time to migrate Virtual Machines also maintaining the QOS.

The contribution of this work is to reduce the Virtual Machine usage by Virtual Machine consolidation with heuristic algorithms. To maintain the quality of service, the utilization threshold is fixed to 85%. The Virtual Machine utilization of the system is tested with PeSoA, PSO and Memetic algorithms on Intel Xeon processors. The energy consumption of the system is compared upon applying the different algorithms. The rest of the paper is organized as follows. Section 2 PeSoA, Section 3 PSO, Section 4 Memetic Algorithm, Section 5 Power calculation and comparisons and Section 6 Conclusion.

2.0 VM CONSOLIDATION USING PENGUIN SEARCH OPTIMIZATION ALGORITHM (PESOA)

This reflects the prey hunting behavior of penguin[8][9]. The food searching phenomenon of penguins is a collaborative distributed model where penguins move in search for their food in groups. The groups will be communicating with each other about the availability of food in the particular region, oxygen level and the food taken by them. Based on this information the other penguins move to the high availability region for taking its food. The room for groups is limited and once there is no new accommodation for a penguin in a group, it will start moving to a group that will be having the best availability. The dive of penguins is random within the group and it is not limited to single dive. The best food availability is identified by the group that consumed a large amount of food.

Virtual Machine consolidation is done with respect to the penguin's behavior of selecting food resource. Here the behavior of food selection depends on the Virtual Machine's CPU and Memory availability as parameters. The algorithm for Virtual Machine consolidation is listed below.

```

Create population of  $VM_{list}$  of  $N$  VMs in groups;
Initialize the VM availability with respect to CPU and RAM
While (Best solution is found) do
  For each  $VM \in VM_{list}$  do
    While (utilization  $\leq 85\%$ ) do
      Consolidate VM.
      Update the current status of VM.
    End while
  End for
  Update the best solution.
  Make VM sleep state if under utilized
End while.

```

Fig.1 PESOA Algorithm

3.0 VM CONSOLIDATION USING PARTICLE SWARM OPTIMIZATION (PSO)

Particle Swarm Optimization (PSO) is a intelligent technique proposed by Kennedy and Eberhart 1995[10]. This is formulated based on the behavior of flock birds. The social behavior in a group and the communication capacity is inspired in this algorithm. The velocities and position of the swarm is updated and communicated for the best solution. A global neighborhood gBest is used to share information globally and local neighborhood lBest is used to share the information locally. The position of the particle updated is based on the current position, new position and best position.

$$Velocity_{new} = Velocity_{current} + (Position_{best} - Position_{current}) + (Position_{neighborBest} - Position_{new}) - (I)$$

$$Position_{new} = Position_{current} + Velocity_{new} - (II)$$

The algorithm for PSO is given below.

```

Initialize array of  $VM_{list}$ 
  For each VM in  $VM_{list}$  evaluate fitness function with respect to CPU and RAM
  availability
  Check the VM fitness with pBest.
  Assign the best value to pBest
  Check the fitness with the gBest
  Assign the best value to gBest
  Change the positions based on (I) and (II)
Iterate the steps till best solution is reached.

```

Fig.2 PSO Algorithm

4.0 MEMETIC OPTIMIZATION

Memetic Algorithms[11] are a hybrid of evolutionary algorithms with a local search to accelerate the findings of good solutions. With the help of this, a closer solution can be replaced with a best solution. Memetic Algorithms uses meme that continuously check for individual improvement as well as global improvement. This algorithm is also very much popular because it will make use of all available information about the problem under study. The initial population of Memetic Algorithm is taken at random. The good featured individuals from the population are selected for the next generation. A local search like hill climbing method will enhance the generation. The algorithm used is given below.

```

Initialize the population_size and Maximum_size
Initialize the Virtual Machines(Population)
While(!Best solution)
    Extract the best Virtual Machines
    Perform LocalSearch
End While
Apply the best solution as the global solution

LocalSearch:

While(!Best Solution)
    New_solution=neighbors(Best_solution)
    If New_solution is best
        Best_solution=New_solution(local best)
    End If
End While

```

Fig.3 MEMETIC Algorithm

5.0 POWER USAGE CALCULATION

The power consumption at the datacenter is measured in PUE (Power Usage Effectiveness) this gives out how effectively the power utilization is done on the datacenters. The power usage effectiveness of a data center is calculated using the formula

$$PUE = \text{Total Facility Power} / \text{IT Equipment Energy}$$

If the PUE value is in the range 1 to 1.8, then the Datacenter is considered to be power efficient.

The total facility power is equal to the power consumed by the IT equipments and the other equipments supporting the IT infrastructure. This includes the power for cooling, lighting, UPS charging power etc.

IT Infrastructure power consumption mainly includes the power consumption by the CPUs, Memory Storage Devices and Network devices. Cooling system consumes the most of the power in the Datacenter. If the heat produced at the datacenter is reduced, the major part of electric consumption (for cooling) can be reduced. This requires an efficient way of utilizing the Datacenter Virtual Machines.

The power consumed at each Virtual Machine can be calculated with the formula given below [11]

$$E_{VM} = \alpha_{cpu} U_{cpu} + \alpha_{mem} U_{mem} + \alpha_{disk} U_{disk} + \gamma - 1$$

Where α and γ are the model specific constant.

U_{cpu} is the power utilization at CPU

U_{mem} is the power utilization of Memory

U_{disk} is the power utilization of Storage Device

6.0 RESULTS AND DISCUSSION

The algorithms are tested with Cloud Sim which is a Library for Simulation of Cloud Computing Scenarios. The feature for support in modeling and simulation of large scale cloud computing infrastructure, including data centers is the reason to choose the tool. It provides basic classes for describing data centers, virtual machines, applications, users, computational resources, and policies. The Cloud Setup was done with X86 - 2 core processor with 1860 Mhz and varying RAM. The performances of the algorithms are compared here. The system is simulated with varying workloads and the comparison of the same is charted below. The power utilization model of the machine at different utilization level is available at [13].

Table 1: Virtual Machine Utilization by PESOA, PSO and MEMETIC

Total Virtual Machines allocated in the system	VM usage with PESOA	VM usage with PSO	VM usage with MEMETIC
30	28	24	18
50	48	42	28
80	78	62	40

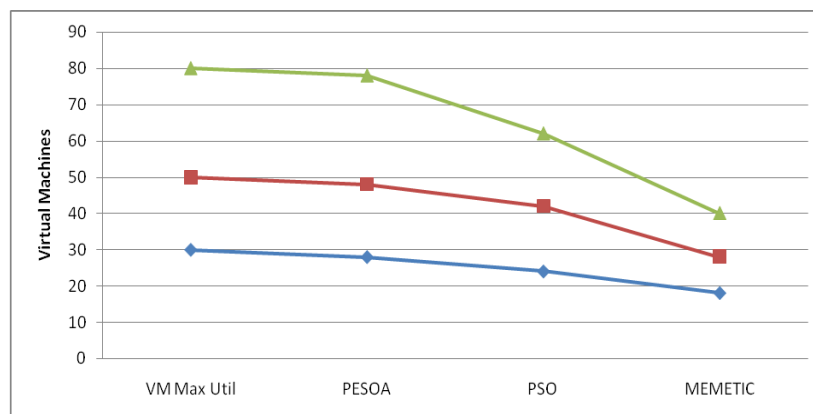


Fig.4 Virtual Machine Utilization by PESOA, PSO and MEMETIC

The results show the number of Virtual Machines used on different loads. On comparing the three algorithms the Memetic algorithm performs better than the PeSoA and PSO in terms of the Virtual Machine usage.

The power estimation of the virtual machines is calculated as given below. The utilization level is fixed to 80% in order to maintain performance. Taking the case here with maximum virtual machine assignment, the maximum total power required by the machine without algorithms at 80% load will be

$$E_{vm} = 157 \text{ W as per [13]}$$

Now the percentage reduction in the utilization of the algorithms PESOA, PSO and MEMETIC is 2.5, 22.5 and 50 percentage respectively. The power utilization of the algorithms is plotted below.

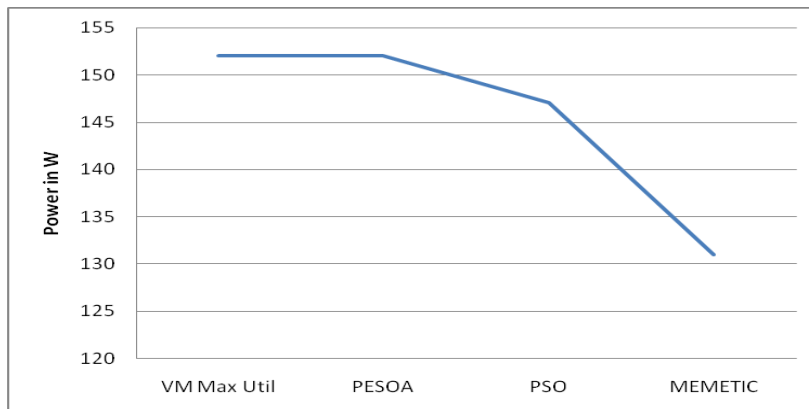


Fig.5 Power Utilization of PESOA, PSO and MEMETIC in Watts

The Carbon emission per kW based on coal based power generation system is 0.87 [12]. Carbon Footprint is calculated with the below formulae C_f .

$$C_f = P_{\text{uesd}} (\text{kW}) * C_{\text{emitted}} (\text{kg/kW}) \text{ and (Saved Power) } P_s = P_{\text{actual}} - P_{\text{uesd}}$$

Table 2: Power usage in KVA and Carbon Footprint in Kgs

Algorithm Vs Power Usage	Power Usage (kW)	Carbon footage (Kgs)
VM	1.52	1.32
PesoA	1.50	1.30
PSO	1.47	1.27
Memetic	1.31	1.13

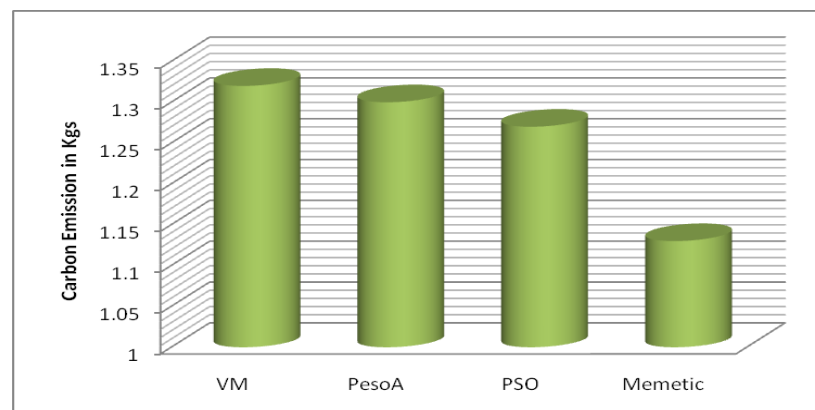


Fig.6 Carbon Footprint in Kgs

The graph clearly shows that Memetic approach saves power or in the other sense, the carbon foot print is greatly reduced when compared with the other algorithms.

7.0 CONCLUSION

The excessive usage of cloud platform is indirectly consuming large power at the datacenter which is leading to a great share in the carbon footprint. A detailed study on the virtual machine consolidation to reduce the VM usage at the datacenter is studied and tested with PeSoA, PSO and Memetic algorithms. The study resulted with Memetic algorithm as a great savior for the carbon footprints at the datacenter. The study will be extended further considering the other parameters affecting the VM consolidation and QOS.

REFERENCES

- [1] J. Koomey, Growth in Data Center Electricity Use 2005 to 2010. Analytics Press, 2011.
- [2] C. Gu, H. Huang and X. Jia, "Power Metering for Virtual Machine in Cloud Computing-Challenges and Opportunities," in IEEE Access, vol. 2, no. , pp. 1106-1116, 2014. doi: 10.1109/ACCESS.2014.2358992
- [3] Hannah Nithya.S, Ms.Rose Rani John,"A Survey on Various Power Measuring Techniques for a Virtual Machine", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 3, Issue 12, pp. 374-377, December 2013,
- [4] R. N. Calheiros, R. Ranjan, A. Beloglazov, C. A. F. D. Rose, and R. Buyya, "CloudSim: A toolkit for modeling and simulation of Cloud computing environments and evaluation of resource provisioning algorithms," Software: Practice and Experience, vol. 41, no. 1, pp. 23–50, 2011
- [5] F. Farahnakian et al., "Using Ant Colony System to Consolidate VMs for Green Cloud Computing," in IEEE Transactions on Services Computing, vol. 8, no. 2, pp. 187-198, March-April 1 2015. doi: 10.1109/TSC.2014.2382555
- [6] N. Bobroff, A. Kochut and K. Beaty, "Dynamic Placement of Virtual Machines for Managing SLA Violations," 2007 10th IFIP/IEEE International Symposium on Integrated Network Management, Munich, 2007, pp. 119-128. doi: 10.1109/INM.2007.374776
- [7] Beloglazov and R. Buyya, "Managing Overloaded Hosts for Dynamic Consolidation of Virtual Machines in Cloud Data Centers under Quality of Service Constraints," in IEEE Transactions on Parallel and Distributed Systems, vol. 24, no. 7, pp. 1366-1379, July 2013. doi: 10.1109/TPDS.2012.240
- [8] Gheraibia Y., Moussaoui A. (2013) Penguins Search Optimization Algorithm (PeSOA). In: Ali M., Bosse T., Hindriks K.V., Hoogendoorn M., Jonker C.M., Treur J. (eds) Recent Trends in Applied Artificial Intelligence. IEA/AIE 2013. Lecture Notes in Computer Science, vol 7906. Springer, Berlin, Heidelberg
- [9] Dian Palupi Rini, Siti Mariyam Shamsuddin and Siti Sophiyati Yuhani. Article: Particle Swarm Optimization: Technique, System and Challenges. International Journal of Computer Applications 14(1):19–27, January 2011
- [10] J. Kennedy and R. Eberhart, "Particle swarm optimization," Neural Networks, 1995. Proceedings., IEEE International Conference on, Perth, WA, 1995, pp. 1942-1948 vol.4. doi: 10.1109/ICNN.1995.488968
- [11] H. A. Sanusi, A. Zubair, R. O. Oladele, "Comparative Assessment of Genetic and Memetic Algorithms", Journal of Emerging Trends in Computing and Information Sciences, vol.2. no. 10. pp. 498-508, October 2011
- [12] Shiv Pratap Raghuvanshi, Avinash Chandra, Ashok Kumar Raghav, "Carbon dioxide emissions from coal based power generation in India", Energy Conversion and Management, ELSEVIER, Volume 47, Issue 4, March 2006, Pages 427–441
- [13] http://www.spec.org/power_ssj2008/results/res2011q1/power_ssj2008-20110127-00342.html
- [14] Chenn-Jung Huang, Chin-Tai Guan, Heng-Ming Chen, Yu-Wu Wang, Shun-Chin Chang, Ching-Yu Li, Chuan-Hsiang Weng, "An Adaptive Resource Management Scheme in Cloud Computing", ELSEVIER – Engineering Applications of Artificial Intelligence, 2012
- [15] Tom Guerout, Thierry Monteil, Georges Da Costa, Rodrigo Neves Calheiros, Rajkumar Buyya, Mihai Alexandru, "Energy-aware simulation with DVFS", ELSEVIER – Simulation Modelling Practice and Theory, 2013

- [16] Divya N, Suprakash S, Balakannan S P, "An efficient VM Consolidation using Penguin Search Optimization Algorithm (PeSOA) for making Cloud Greener" IEEE, 978-1-4673-9939-5/16/2016
- [17] Josphin, Suprakash S, Balakannan S.P, "An Optimal Virtual Machine Assignment Using Firefly Algorithm For Achieving Energy Efficiency In Data Centre", International Journal of Applied Engineering Research", pp. 3991-3994, 2015.
- [18] Karuppasamy M., Suprakash S., Balakannan S. P., "Energy Efficient Cloud Networks Towards A Sustainable Green Environment", International Journal of Research in Engineering & Advanced Technology, Volume I, Issue 1, March, 2013
- [19] A. Berl, E. Gelenbe, M. Girolamo, G. Giuliani, H. Meer, M. Dang, and K. Pentikousis, "Energy-efficient cloud computing", The Computer Journal Advance Access, August-2009.
- [20] Miguel Caballer, Carlos de Alfonso, Fernando Alvarruiz, German Molto, "EC3: Elastic Cloud Computing Cluster", ELSEVIER – Journal of Computer and System Sciences, 2013

