Analysis on energy efficient green cloud computing

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Abstract. Cloud computing offers subscription based storage and resources. Cloud computing provides various services to cloud users. Increased use of information and communication technologies (ICT) has led to increase energy cost as well also increased emission of greenhouse gases like CO2. Since energy is an important asset, green cloud computing comes into picture. Green cloud computing can be achieved by applying various approaches, which uses lesser power as well as emits less CO2 gas, which is hazardous to environment. Energy efficient technologies results in decreased overall energy consumption. There is a need of data centre in almost every field like web applications and businesses which results in producing huge amount of CO2 in environment. To make data centres environment friendly we need energy efficient approaches which will reduce energy consumption and there hazardous effects on environment. Data is being generated at very high speed so the need of data centres will also increase. Increased data centres will then consume more amount of energy. The main objective of these paper is to reviews various approaches applied by researchers to make energy efficient cloud computing.

1. Introduction
Green computing is a way to make data centres eco-friendly. Firms that uses cloud computing needs to be answerable about better environment. Many of IT as well as non IT companies have started to take actions to make eco-friendly environment. Without much investment on infrastructure one can do all computations and storage services on demand.

Increasing demand of customers for these pay as per use resources are resulting to create more power hungry data centres. Data centre requires huge amount of power to run various equipment’s including monitor, cooling fan and other peripherals. Energy consumption of data centre is kept on increasing day by day. Total power consumption of data centres over whole world has went from 70000 million to 330000 million kWh from 2000 till 2007 and it is predicted that by 2020 it can grow to more than 1000000 million kWh. Consumption of enormous amount of energy in data-centres is major issue in cloud computing. Environment is in danger due to emission of harmful gases like CO2 from data centres. Hence green cloud computing is playing great role to make computing environmental friendly.

Virtualization is a key technology for cloud computing environment. For efficient use of software and hardware utilities cloud computing applies virtualization concept. VM Consolidation is the act of energy consumption reduction in data centers thereby assigning VMs to the lesser servers as much as possible. Many researches has been conducted on VM consolidation with the aim of reducing energy consumption of data centres. Open-source consolidation framework named as OpenStack Neat is a framework which is remarkable for its practicability has components which has proven helpful for
deciding when to migrate VM as well as selection of suitable host for relevant VM. OpenStack Neat has VM placement algorithmic program referred to as Modified Best-Fit Decreasing. These algorithm relies on a examining which is less energy efficient and it conjointly increases service level agreement (SLA) violation due to additional VM migrations. Researchers then come up with some other VM placement algorithms to address limitations of present VM placement regarding to factors like energy-efficiency, migrations of VM and violation of SLA. On the basis of both bin-packing heuristics and power efficiency of servers to cultivate the power efficiency, VM placement algorithms has been proposed by researchers. Cloud users point of view towards cloud computing is just fulfilment of their demands without much delay. A proper-balanced energy efficiency and service level agreement assurance is needed to call any consolidation algorithm as a good consolidation algorithm. Four decision components of OpenStack Neat are:
1. Identifying overloaded host
2. Identifying under loaded host.
3. Selection of VM.
4. Placement of VM.

Algorithms like Modified Best-Fit Decreasing (MBFD), Efficient Power First-Fit Decreasing (PEFFD) algorithm, Efficient Power Best-fit Decreasing (PEBFD) algorithm, Medium-fit power efficient decreasing (MFPED) algorithm are tested and their performance has been evaluated. We have carried experiments using simulator called CloudSim to analyze performance of algorithms.

2. Literature Review
Energy consumption and carbon emission problems are problems which IT industry is facing since several years. In recent years, with the evolution of new techniques, cloud computing has found to be a helpful solution to environmental problems as per X. Yu, Y. Ma and J. Li(2018)[11]. Paper provides a way to verify cloud computing can be really helpful to reduce energy consumption problems from aspect by applying CLEER model to calculate carbon emission.

Cloud computing has made associate an excellent way to virtualize servers to form energy efficient data centre in order to capitalize numerous IT resources. Many analysis issues associated to Green DC, Various objectives etc. are elaborated using comparative analysis of Greener-IT ways within the literature[2].

In the work of Moges, F., Abebe, S.(2019)[3], Researchers address limitations of present VM placement algorithms present in OpenStack Neat framework with concernedly of energy-efficiency, migrations of VM and violation of SLA. OpenStack Neat could be a dynamic merger approach that may easily combine to OpenStack. It’s one in all the foremost commonly used cloud management tool which is open source.

Saad Mustafa , Kinza Sattar developed SLA-Aware Best Fit Decreasing methods for Work Consolidation in Clouds[4] consistent with various analysis sorting of tasks in Modified Best-Fit decreasing (MBFD) algorithm is quite like BFD algorithm. In this research, energy-efficient techniques has presented , two consolidation based EE techniques that not only reduces energy consumption but resultant SLA violations too. MBFD still have certain limitation which has been address in literature[3].

One of main reason behind energy inefficiency is low utilization of physical server according to Y. Chang (2017)[5]. Researchers has aimed to assist the utilization of servers, a novel VM allocation policy supported resource-aware utility model is projected to boost the consolidation efficiency. A Power-Aware technique which is dependent on Particle Swarm Optimisation (PAPSO) to see the near-optimal placement for the migrated VMs is projected by A. Ibrahim(2020)[6].

Comparative analysis on Virtual Machine assignment algorithms [7] is conducted by Priyanka C.P and S. Subbiah. Survey paper offers an summary of the prevailing VM placement techniques conjointly the projected arbitrary resource allocation algorithmic program to scale back resource wastage and power consumption and it also provides load equalization in servers.
F. Shakeel and S. Sharma (2017) [[8]] conducted evolution on efficiency of information centers and server’s virtualization. The basic purpose of this evolution is to research the various techniques that are enforced to scale back energy consumption by cloud computing. Performance improvement has invariably been considered however the increase in power consumption of computing systems and emission of greenhouse gas within the environment has restricted rise of performance.

3. Summary of various algorithms
There are number of VM placement algorithms researched by a researcher which has proven effective in minimization of power consumption as well as minimizing SLA violation.

Comparative analysis of some of algorithms is shown further using bar graph.

For improving power efficiency, reduce migrations of VM as well as violation of SLA researchers has proposed an improvement to the OpenStack Neat consolidation. Proposed algorithms also have addressed the limitation of MBFD by altering the bin-packing method and analysing host’s power efficiency.

3.1. Modified Best-Fit Decreasing (MBFD) Algorithm
Virtual machine consolidation is one of the effective way for energy efficient data centres. Modified Best-Fit Decreasing (MBFD) is VM placement algorithm of OpenStack Neat.

MBFD algorithm takes input as VM list to be place, list of active host as well as inactive host while algorithm gives output as a VM placement algorithm. Algorithm sorts VM list in decreasing order of CPU utilization. MBFD algorithm selects an host from host list which has minimum available CPU that can fits the current VM. In case of a tie, the host which has smallest RAM available is considered.

```
// Algorithm 1. Modified Best-Fit Decreasing (MBFD) Algorithm
Input: activeHostList, inactiveHostList, vmList
Output: vmPlacement
1. sort vmList in the order of decreasing average CPU utilization;
2. foreach vm in vmList do
   3. minCPU ← MAX;
   4. allocatedHost ← NULL;
   5. foreach host in activeHostList do
      6. if host has enough resources for vm then
         7. cpu ← getAvailableCPU(host);
         8. if cpu < minCPU then
            9. allocatedHost ← host;
            10. minCPU ← cpu;
         11. else
            12. if cpu == minCPU and
                getAvailableRAM(host) < getAvailableRAM(allocatedHost)
                then
                13. allocatedHost ← host
                end
   14. end
   15. if allocatedHost ≠ NULL then
      16. add (allocatedHost, vm) to vmPlacement;
      17. else
         18. // assign allocatedHost from inactive hosts
         19. minCPU ← MAX;
         20. allocatedHost ← NULL;
         21. foreach host in inactiveHostList do
            22. if host has enough resource for vm then
               23. cpu ← getAvailableCPU(host);
               24. if cpu < minCPU then
                  25. allocatedHost ← host;
                  26. minCPU ← cpu;
               27. else
                  28. if cpu == minCPU and
                     getAvailableRAM(host) < getAvailableRAM(allocatedHost)
                     then
                     29. allocatedHost ← host
                     end
               30. end
            31. end
            32. if allocatedHost ≠ NULL then
               33. add (allocatedHost, vm) to vmPlacement;
               34. end
         35. end
         36. Result: vmPlacement
```

3
Above algorithm of VM consolidation consolidates VMs on lesser number of servers. It reduces energy consumption by placing underutilized servers turn off or put it in sleep mode. Although, the algorithm has certain drawbacks too: (i) Overload probability increases when VM is placed in most utilized host. The overload will result in increased SLA violations and number of VM migrations, and (ii) In a heterogeneous cloud environment, the MBFD algorithm will be less energy efficient.

3.2. **Energy Efficient First- Fit Decreasing (PEFFD) Algorithm**

Proposed VM placement algorithm contains bin packing heuristics as well as power efficiency of host is calculated. Energy Efficient First- Fit Decreasing (PEFFD) Algorithm is grounded on bin packing model called first. First-Fit (FF) bin packing heuristic first assign an item to bin which is first partially open. That fits in, otherwise new bin is open.

![Algorithm 2. Energy Efficient First- Fit Decreasing Algorithm](image)

As shown above, EEFFD algorithm requires input as the list of VM to be migrate and the host list to allocate VMs. As per line 1 of above algorithm, Each VM in VM list is sorted in non increasing order of utilization of CPU i.e. decreasing resource demand. Line 5-13 of given algorithm searches host from active host list, if host from active host list has resource for the VM then power efficiency of host is calculated, best host for VM placement is determined by repeatedly checking and replacing allocatedHost with one which has best power efficient host. In PEFFD, in case of tie regarding power efficiency one which has lowest index is chosen. According to line 15, finally a VM and the best host are added to a vmPlacement map. Same process is repeat for host from inactive host list using the same process, in case if active host is not found for a VM placement, then (line 16-31).

3.3. **Energy Efficient Best- Fit Decreasing Algorithm**

EEBFD algorithm uses bin packing approach called best fit. PEBFD works more like PEFFD but as its name suggest, it is grounded on approach of bin packing called best-fit. PEBFD algorithm takes
input same as PEFFD list of VM to be migrate and host list to allocate VMs. PEBFD finds host as a better host for VM placement than other host if it has power efficiency (PE) greater than any other host. In case of tie, Host which is having lowest CPU available is chosen.

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3.4. Medium Fit Energy Efficient Decreasing Algorithm
Medium fit energy Efficient Decreasing algorithm is designed by authors to minimize SLA violations as well as number of VM migrations too. MFEED algorithm has threshold levels called overloadthr and underloadthr which are resource utilization levels.

L = (overloadthr + underloadthr) / 2; Where, L be preferred level of resource utilization of a host. Host which has resource level minimum from resource utilization level.
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Algorithm 3. Energy Efficient Best- Fit Decreasing (PEBFD) Algorithm
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Algorithm 4. Medium Fit Energy Efficient Decreasing Algorithm
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As per above algorithm, any host is considered as superior host for allocation of VM than any of another if it has less distance for CPU utilization level from the desired level as compare to any other host as per line 8-12. In case of tie, the host with higher PE is taken into consideration and allocated host and vm is added to vmplacement map.

4. Experimental setup and Results

Above algorithms is simulated using cloudsim simulator. It is associate degree open source stage that aid in the implementing Resource Allocation concept within the cloud environment. Classes available in above algorithm extend PowerVmAllocationPolicyMigrationLocalRegression class which is available in power package of simulator. Workload is generated from traces of PlanetLab cloud. Experimental results of algorithms are as shown below:

4.1. Modified Best-Fit Decreasing (MBFD) Algorithm

4.2. Medium-Fit Energy Efficient Decreasing (MFPED) Algorithm
4.3. Energy Efficient Best- Fit Decreasing (PEBFD) Algorithm

4.4. Energy Efficient First- Fit Decreasing Algorithm
Above bar charts clearly shows the comparison of various algorithms based on aspects such as energy consumption as well as SLA violation of algorithm. As far as energy consumption of algorithms is concern, MBFD consumes more energy as compare to other algorithms.

MBFD algorithm also has more SLA violation as compare to other three algorithms, MFPED has comparatively lower SLA violation.
5. Conclusion
As part of my research analysis on green cloud computing, I have presented the literature review on energy efficient green cloud computing. I have briefly explored the concept of cloud computing and the need of designing the green clouds. Literature review presented by the research scholars conducted researches on green clouds; their research identified limitations and proposed solutions.

Several researches have been conducted to address challenges like energy consumption using VM consolidation technique. In the method of VM consolidation energy consumption is minimized by placing VM in fewer range of physical machines.

In research researchers address problem of consolidation by altering bin packing heuristic and estimating each host’s power efficiency. With comparison of baseline algorithm called MBFD, algorithms mentioned above are more power efficient. I have used cloudsim 3.0.3 for experimentation.

6. References
[1] X. Yu, Y. Ma and J. Li, "Analysis and Research on Green Cloud Computing," 2018 2nd IEEE Advanced Information Management, Communicates, Electronic and Automation Control Conference (IMCEC).
[2] Y. S. Patel, N. Mehrotra and S. Soner, "Green cloud computing: A review on Green IT areas for cloud computing environment," 2015 International Conference on Futuristic Trends on Computational Analysis and Knowledge Management (ABLAZE), Noida, 2015, pp. 327-332, doi: 10.1109/ABLAZE.2015.7155006.
[3] Moges, F., Abebe, S. “Energy-aware VM placement algorithms for the OpenStack Neat consolidation framework”. J Cloud Comp 8, 2 (2019).
[4] S. Mustafa et al.,, "SLA-Aware Best Fit Decreasing Techniques for Workload Consolidation in Clouds," in IEEE Access, vol. 7, pp. 135256-135267, 2019, doi: 10.1109/ACCESS.2019.2941145.
[5] Y. Chang, C. Gu and F. Luo, "Energy efficient virtual machine consolidation in cloud datacentres." 2017 4th International Conference on Systems and Informatics (ICSAI), Hangzhou, 2017, pp. 401-406, doi: 10.1109/ICSAI.2017.8248325.
[6] A. Ibrahim, M. Noshy, H. A. Ali and M. Badawy, “PAPSO: A Power-Aware VM Placement Technique Based on Particle Swarm Optimization,” in IEEE Access, vol. 8, pp. 81747-81764, 2020.
[7] Priyanka C.P and S. Subbiah, "Comparative analysis on Virtual Machine assignment algorithms," 2017 2nd International Conference on Computing and Communications Technologies (ICCTCT), Chennai, 2017, pp. 204-209, doi: 10.1109/ICCTCT.2017.7972279.
[8] F. Shakeel and S. Sharma, "Green cloud computing: A review on efficiency of data centers and virtualization of servers," 2017 International Conference on Computing, Communication and Automation (ICCCA), Greater Noida, 2017, pp. 1264-1267, doi: 10.1109/ICCCA.2017.8230012.
[9] M. N. Kavyasri and B. Ramesh, "Comparative study of scheduling algorithms to enhance the performance of virtual machines in cloud computing," 2016 International Conference on Emerging Trends in Engineering, Technology and Science (ICETETS), Pudukkottai, 2016, pp. 1-5, doi: 10.1109/ICETETS.2016.7602980.
[10] P. D. Bharathi, P. Prakash and M. V. K. Kiran, "Virtual machine placement strategies in cloud computing," 2017 Innovations in Power and Advanced Computing Technologies (i-PACT), Vellore, 2017, pp. 1-7, doi: 10.1109/iPACT.2017.8244949.
[11] M. Wadhwa, A. Goel, T. Choudhury and V. P. Mishra, "Green Cloud Computing - A Greener Approach To IT," 2019 International Conference on Computational Intelligence and Knowledge Economy (ICCIKE), Dubai, United Arab Emirates, 2019, pp. 760-764, doi: 10.1109/ICCIKE47802.2019.9004283.
[12] Patil, Archana and Patil, Dr. Rekha, An Analysis Report on Green Cloud Computing Current Trends and Future Research Challenges (March 19, 2019). Proceedings of International Conference on Sustainable Computing in Science, Technology and Management (SUSCOM), Amity University Rajasthan, Jaipur - India, February 26-28, 2019.
[13] Kaushal S., Gogia D., Kumar B. (2019) Recent Trends in Green Cloud Computing. In: Krishna C., Dutta M., Kumar R. (eds) Proceedings of 2nd International Conference on Communication, Computing and Networking. Lecture Notes in Networks and Systems, vol 46.
[14] Masdari, M., Zangakani, M. Green Cloud Computing Using Proactive Virtual Machine Placement: Challenges and Issues. J Grid Computing (2019)
[15] Shuja, J., Ahmad, R.W., Gani, A. et al. Greening emerging IT technologies: techniques and practices. J Internet Serv Appl 8, 9 (2017).