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EVMPCSA: Efficient VM Packing mechanism in cloud computing using Chaotic Social Spider Algorithm

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Abstract

VM packing is one of prodigious challenge in cloud computing as it depends on the incoming workload onto virtual resources. Workload in the cloud is highly dynamic and it is difficult to predict the upcoming tasks and place them properly onto an appropriate VM is a challenging task. While scheduling workload onto VMs it is important to pack them in an appropriate physical machine because there is a chance of wastage of virtual resources and which leads to high energy consumption. Therefore, it is necessary to pack VMs into an appropriate Physical machines based on utilization of CPU. Many of authors proposed various consolidation techniques to assess parameters makespan, energy consumption, Througput but still there is a research gap and we can minimize energy consumption based on utilization of CPU in proposed approach i.e. EVMPCSA. Consolidation of VMs and chososing of VM for migration onto a Physical host is based on utilization of CPU.Chaotic Social Spider algorithm is used as a methodology for VM packing mechanism. EVMPCSA uses cpu utilization as constraint and used Chaotic Social Spider algorithm as methodology in this work to solve VM packing problem.It is simulated on Cloudsim and evaluated aganist existing algorithms named as PSO,CS and ACO. When it is compared with PSO,CS and ACO makespan is greatly minimizes by 30.25%, 23.5% and 17.31% respectively and energy consumption is minimized for PSO, CS and ACO by 27.6%, 24.78% and 10.09% respectively.

Keywords: VM Packing; Utilization of CPU; PSO; ACO; CS; Energy Consumption; makespan

1. Introduction

Cloud Computing model changed the entire IT sector by delivering services on demandly to users with a seamless experience to users by providing infrastructure, computational, network services on demandly as a utility based services. It is advantageous in many ways as it gives flexibility to cloud users as they can deploy VMs on demandly without any hesitation thereby Scalability will comes into picture which is also an another advantage. In order to provision these services to users seamlessly an effective VM Packing mechanism is needed which can efficiently pack VMs onto appropriate physical machines from which corresponding services are to be pumped for users. In Cloud model, energy consumption plays a major role if incoming tasks demands more VMs then it consumes huge amount of energy consumption as they have to proces s more number of tasks and it also includes power consumption, cooling cost of servers. If the incoming workload is less then it is waste of using so many VMs and servers. Therefore, there

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is a need of packing of VMs into a Physical machine based on their utilization of CPU. A leading Cloud service provider Amazon reported that their energy related costs is 42% of their total budget which is a huge investment[1]. Therefore, It is a serious issue to deal with energy consumption in datacenters as it may also leads to release more CO_2 which pollutes environment. Therefore, it is our responsibility to reduce consumption of energy in datacenters through which we can achieve green computing perspectives. To reduce consumption of energy at datacenters many of authors proposed various consolidation strategies which can minimize energy consumption but still there is a chance to minimize energy consumption based on utilization of CPUs. Earlier authors proposed consolidation mechanisms using nature and bio inspired algorithms i.e. PSO[2], CS[3], ACO [4]. These authors addressed parameters makespan, throughput, energy consumption but still there is a need to improve the packing of VMs with respect to minimization of energy consumption. For this to happen, we come up with an approach in such a way that proposed approach tracks utilization of CPU and gives status to Scheduler in such a way that whether it is underloaded or overloaded. We have designed this VM packing mechanism using Chaotic Social Spider algorithm [5]. We have implemented our proposed approach i.e. EVMPCSA on cloudsim tool.
The following are important contibutions of this manuscript.

- Developed a VM packing mechanism i.e. EVMPCSA which uses utilization of CPU for packing a VM into an appropriate Physical machine.
- Proposed VM packing mechanism developed based on Chaotic Social Spider Algorithm.
- Implementation of this algorithm carried out on Cloudsim.
- EVMPCSA evaluated aganist existing PSO, CS, ACO algorithms, addressed parameters are makespan, Energy Consumption.

Remaining structure of the manuscript is organized as follows. Section 2 discusses Related Works, Section 3 discusses architecture of EVMPCSA, Section 4 discusses proposed EVMPCSA algorithm, Section 5 discusses Simulation and results and finally Section 6 discusses Conclusion and Future work.

2. Related Works

In [6], proposed a VM Consolidation mechanism which addresses energy efficiency. It mainly developed based on parameters such as reliability and failure rate thereby improving energy consumption. In this work, VMs are consolidated after checking VMs failure rate and chances of hazardness of Physical hosts then VMs can be migrated onto corresponding Physical host. This work was implemented on Matlab and addresses parameters such as reliability and failure rate. From results, it was identified that reliabilty was improved by 34% and failure rate was minimized by 14%. In [7], developed a VM Consolidation mechanism which addresses power consumption. Genetic algorithm was for developing this algorithm. It was implemented on customized cloud environment. Finally it was evaluated aganist FF, FFD, PP algorithms. From simulation, it was observed power consumption minimized greatly while consolidating VMs effectively. In [8], designed a dynamic VM Consolidation mechanism which is developed based on space aware best fit decreasing algorithm addresses energy consumption, SLA violation and performance degrdation. This model was implemented on cloudsim and real world workload traces are used in simulation. It was evaluated aganist PABFD policy and from results, it was noted that above mentioned parameters were minimized to great extent. In [9], formulated a VM consolidation framework which addresses execution time,number of SLA Violations, Number of VM migrations. ACO algorithm was used as methodology for this approach. It was implemented on cloudsim tool. It was evaluated aganist FFD, ST and MGA algorithms and finally from results it came to know that it was outperformed over them for mentioned parameters. Energy efficient consolidation mechanism was formulated in [10] which addresses number of SLA violations, number of VM migrations. Initially corresponding server's workload should be detected whether it is overloaded or underloaded based on that VMs can be consolidated by migrating into appropriate physical machines. Cloudsim was used as simulation environment to implement this mechanism. It was compared over existing approaches IQR and LR. From simulations, EES outperformed over existing approach for above parameters. A dynamic multi objective VM Consolidation technique developed to address reliability and QOS issues. For addressing reliability issues they have used DTMC model to predict upcoming workload to allocate resources for them. MACO was used as methodology to design this mechanism. It was implemented on cloudsim tool and evaluated aganist variations of ACO and finally from results it was outperformed aganist existing variations. An algorithm designed in [12] which addresses parameters energy consumption, communication overhead and migration cost. Iterarive budget algorithm was used as methodology to design consolidation mechanism. It was used to concentrate on budget and target selection of appropriate physical machine. It was implemented on cloudsim tool. It was evaluated aganist existing baseline heuristics and identified that this approach improves above mentioned parameters in a better way. In[13], a ML approach was used to consolidate VMs in an effective way. It addresses mainly energy consumption and SLA violation. It uses a reinforcement Learning approach to do consolidation. Authors have compared various Reinforcement learning strategies by using different realtime workloads. Finally, it was compared with various empircial algorithms and came to know that energy efficiency improved by 25% and minimized SLA violation by 63%. In[14], a VM consolidation mechanism was deigned to avoid over consolidation which leads to violations of SLA, huge consumption of energy. Linear regression model used to develop consolidation model. cloudsim toolkit used as simulator, when it compared with baseline approaches consumption of energy minimized to 25%, violations of SLA minimized to 99%. In [15], a dynamic VM consolidation technique was designed in such a way that when VM is migrated from one physical host to another it checks utilization of CPU, a variable which indicates resource selection sastisfaction. VM selected for migration to a host also need to have a minimum correlation with host. This was implemented on cloudsim toolkit and for simulation realworld workload traces were considered. Finally it was compared with baseline algorithms and from results SLA violation, migration time and energy efficiency were greatly minimized. VM consolidation technique developed in [16] using cuckoo optimization. It address parameters such as migration cost and energy cost. Group technology was used in cuckoo optimization. This group technology based on laying of eggs, immigration cuckoos. Extensive simulations were ran by using cloudsim toolkit. It was evaluated aganist RR, FF approahces. Finally from simulation, great impact was shown over existing mechanisms. From above literature review and from table 1 got an insight i.e. many of authors addressed various parameters makespan, SLA violation, energy consumption but still VMs can be effectively consolidated based on considering utilization of CPU using our proposed approach while minimizing makespan and energy consumption.

Table 1: Analysis of Existing works done by various authors.

Authors	Methodology (t)	Parameters (t)
[6]	RAA	Reliability,failure rate
[7]	GA	Power Consumption
[8]	SBFDA	Energy Consumption
[9]	ACO	SLA Violation
[10]	EECM	SLA Violation
[12]	IBA	Energy Consumption
[13]	ML Technique	Energy Consumption
[14]	Linear Regression	SLA Violation
[15]	Dynamic VM Consolidation	SLA Violation
[16]	Cuckoo Optimization	makespan, Energy Consumption

3. System Architecture of Proposed EVMPCSA

This section disucsses VM consolidation mechanism mathematically. Initially we have assumed n number of tasks indicated as $t_n = \{t_1, t_2, t_3, ...t_n\}$, k number of VMs indicated as $vm_k = \{vm_1, vm_2, ...vm_k\}$, i number of Physical hosts indicated as $H_i = \{H_1, H_2, ..., H_i\}$ and j number of datacenters indicated as $D_j = \{D_1, D_2, ...D_j\}$. when n number of tasks are coming onto cloud console, these should be carefully mapped to k number of VMs and inturn they are mapped onto i number of physical hosts sitting in j number of datacenters. These are the assumptions in problem and if it happens if any VM is overloaded or underloaded based on utilization of CPU consolidation mechanism need to migrate VM onto an appropriate Physical host while minimizing makespan, energy consumption.

In the above figure, Initially users submits requests to cloud interface where task manager capture requests of users and in turn which is given to scheduler and it schedules tasks. Scheduler will assign appropriate tasks to VMs but in

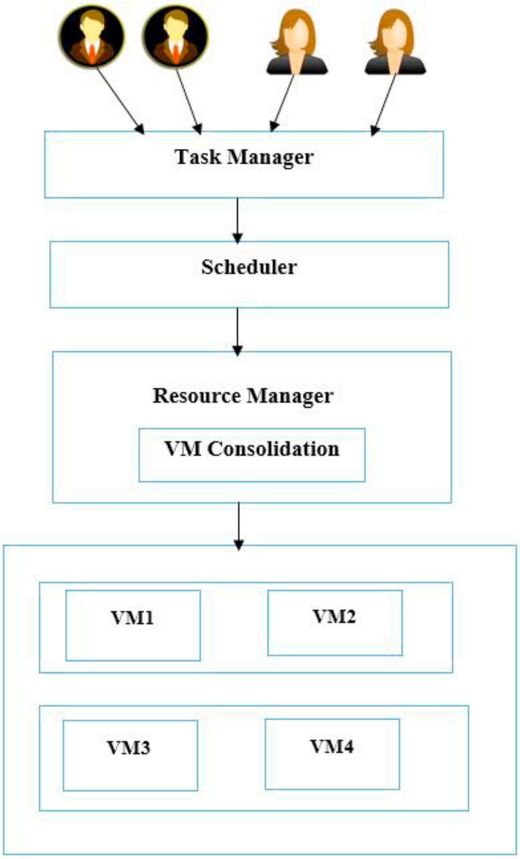

Fig. 1: Proposed System Architecture

between scheduler and VMs there is a component named as Resource manager where it can track utilization of VMs in which how many VMs are utilized, how many tasks currently running in VMs and how many of them are still can be assigned with tasks. In this work, VM consolidation module was integrataed into Resource manager where we have written rules in such a way that it will identify utilization of CPU and gives status of the corresponding VM and based on that consolidation mechanism will decide whether that VM should be migrated to a Physical host or not.

We have defined the following rules for identifying utilization of CPU for VM consolidation. The rules are as follows. If utilization of cpu is < 20% ,VM is in underutilized mode, If utilization of cpu is > 75% then VM said to be in overutilized mode and finally if utilization of cpu is in between 20% and 75% then VM is in balanced mode. After identifying the rules, we are interested in addressing parameters named as makespan, energy consumption. In this following mathematical model we have formulated parameters.

3.1. makespan model

For VM consolidation mechanism choosing a right VM is important to consolidate onto an appropriate Physical host. It is important as it impacts makespan directly as if execution time is more then consolidation mechanism is not effective. Minimization of makespan is one of primary criteria in cloud computing. It is mathematically represented as by following equation.

$$ma_n = ava_k + e_n \tag{1}$$

where ma_n represents makespan of n tasks, ava_k represents availability of k VMs, e_n represents execution time of n tasks.

3.2. Energy Consumption model

When VM consolidation is not effective, if VM is not chosen properly to migrate then if it takes more time to migrate from a Physical host to another then it consumes more energy which directly impacts cloud service provider and indirectly impacts cloud user. In this Subsection, we have carefully formulated energy consumption model below. It is represented below in the following equation.

$$en_{cons} = \sum en_{cons}(vm^k) \tag{2}$$

3.3. Fitness function

In this mathematical model, we have formulated a fitness function through which we optimized parameters i.e. makespan, energy consumption. The below equation indicates fitness function.

$$f(x) = min \sum_x ma_n(x), en_{cons}(x) \tag{3}$$

For optimization of above parameters, we have identified an algorithm named as chaotic social spider algorithm which solves consolidation problem and addresses parameters mentioned in the above fitness function.

3.4. Chaotic Social Spider Algorithm

Chaotic Social Spider algorithm is a nature inspired approach in [17]. It is totally based on foraging pattern of spider web. Spiders looks for a prey by using search agents. Initially spider population generated randomly. Search agents will guide the process of searching for prey. Search agents will communicate among themselves for best solution identification via broadcast messages. This broadcast message calculated as follows.

$$broad^{msg}(T) = \log\left(\frac{1}{f(x) - r} + 1\right) \tag{4}$$

where r is control parameter and it is represented as 0 or 1. After identification of solutions from all search agents best solution is identified from available solutions if it is a better solution from current set of solutions it is represnted as 1 otherwise it is represented as 0. Search agents will look for other preys but not the previous visited search locations.

$$z_{s+1} = \gamma z_s(1 - z_s) \tag{5}$$

From above equation5, z_s represented as random number generator and to search for prey in a proper way rather than searching for previous search space by continuing it in other locations of search space, need to add weights for searching process. It can be given by following equations.

$$m(T + 1) = m(T) + (m(T) - m(T - 1)) * \delta + (m_s - m(T)).\gamma \tag{6}$$

$$\delta(T) = (\lambda_{int} - \lambda_{final}) * \left(\frac{itr_{max} - itr}{itr_{max}}\right) + \lambda_{final} * z_{s+1} \tag{7}$$

From above equation 7, λ_{int},λ_{final} are initial and final weights added to search process. itr_{max} and itr are maximum iterations and current iterations respectively.

4. Proposed Efficient VM Packing mechanism in cloud computing using Chaotic Social Spider Algorithm (EVMPCSA)

Algorithm 1 Proposed Efficient VM Packing mechanism in cloud computing using Chaotic Social Spider Algorithm (EVMPCSA)

Input: $t_n = \{t_1, t_2, t_3, ...t_n\}$, $vm_k = \{vm_1, vm_2, vm_3.....vm_k\}$, $H_i = \{H_1, H_2, H_3....H_i\}$ and $D_j = \{D_1, D_2, D_3....D_j\}$
Output: Consolidation of VMs to appropriate Physical hosts by considering utilization of CPU while minimizing $ma_n(x), en_{cons}(x)$
Start
Generate search agent random population
generation of soultions using eqn 5.
Evaluate utilization of CPU
Updation of Search process using eqn 6.
evaluate fitness function using eqn 3.
Calculate makespan,energy consumption using eqns 1 and 2 respectively
Pick a VM randomly among k VMs
if (identified best solution gives minimized makespan, energy consumption and check for VM status based on utilization of CPU) **then**
  Consolidate the VM to appropriate Physical host based on utilization of CPU
  Update them as minimized makespan, energy consumption.
else
  search for the next VM until the best parameters are identified.
end if
repeat this process until all iterations are completed.
End

Flow of above mentioned algorithm is represented here. Initially Search process for the prey by using search agents initialized randomly. After random generated population, calculate utilization of CPU then solutions can be generated using eqn 5. After generation of solutions fitness function is evaluated using eqn 3. Search process is updated by using eqn 6 and after generation of solutions parameters named as makespan, energy consumption were evaluated and then identify a VM among k VMs and check for VM status. If generated solutions produces minimized parameters update them as best solutions. Check status of VMs and consolidate them to suitable physical hosts based on utilization status of CPU. Repeat this process until all iterations are completed.

5. Simulation and Results

Table 2: Configuration Settings for Simulation.

Name	Quantity (t)
RAM	16GB
No. of Tasks	100-1000
Hard disk	256GB
Physical Host Processor	i5
Length of Tasks	800,000
Hypervisor	Xen
Operating System	Linux
No. of Data Centers	2

This section clearly discusses about simulations and results of EVMPCSA in a detailed way. The above table 2 represents configuration settings of simulation. The entire simulation process is carried out on cloudsim toolkit[18]. This simulator was installed on a machine which consists of i5 intel processor, 16 GB RAM, 256 GB Hard disk. We have iterated our algorithm by using 1000 tasks and all tasks in cloudsim were randomly generated. Configuration settings for simulation were considered from [19] We evaluated efficiency of our algorithm by evaluating aganist PSO, CS, ACO algorithms. Intially our main aim is to consolidate VMs appropriately to Physical hosts by considering utilization of CPU but while doing consolidation we also want to measure makespan, energy consumption. These are evaluated in simulation appropriately which were mentioned in below subsections.

5.1. Evaluation of makespan

This subsection represents calculation of makespan. For this calculation of makespan, we have considered 100, 500 and 1000 tasks. This calculation was evaluated aganist existing PSO, CS, ACO algorithms. Initially, we have considered 100, 500 and 1000 tasks and makespan generated for PSO algorithm for 100, 500 and 1000 tasks are 75.87,87.98,134.95 respectively. Makespan generated for CS algorithm for 100, 500 and 1000 tasks are 59.78,83.67,129.23 respectively. Makespan generated for ACO algorithm for 100, 500 and 1000 tasks are 47.98,81.54,122.56 respectively.Makespan generated for our proposed EVMPCSA algorithm for 100, 500 and 1000 tasks are 33.52,74.56,100.35 respectively. From the above results, it is clearly identified that proposed approach EVMPCSA minimized makespan when it compared over PSO, CS and ACO algorithms. It minimizes for PSO, CS and ACO are 30.25%,23.5% and 17.31% respectively.

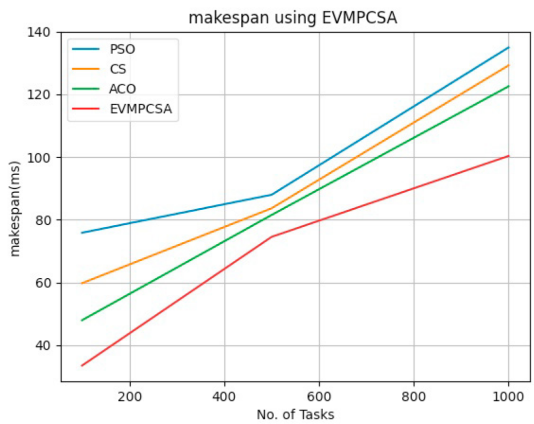

Fig. 2: Calculation of makesan using EVMPCSA

5.2. Evaluation of Energy consumption

This subsection represents calculation of consumption of energy. Calculation of Consumprion of Energy, we considered 100, 500 and 1000 tasks. This calculation was evaluated aganist existing PSO, CS, ACO algorithms. Initially, we have considered 100, 500 and 1000 tasks and energy consumption generated for PSO algorithm for 100, 500 and 1000 tasks are 42.79,85.62,128.98 respectively. Energy Consumption generated for CS algorithm for 100, 500 and 1000 tasks are 52.34,79.98,115.36 respectively. Energy Consumption generated for ACO algorithm for 100, 500 and 1000 tasks are 45.34,53.66,108.23 respectively.Energy Consumption generated for our proposed EVMPCSA algorithm for 100, 500 and 1000 tasks are 39.88,47.21,99.21 respectively. From the above results, it is clearly identified that proposed approach EVMPCSA minimized Energy Consumption when it compared with PSO, CS, ACO. It minimizes for PSO, CS and ACO are 27.6%,24.78% and 10.09% respectively.

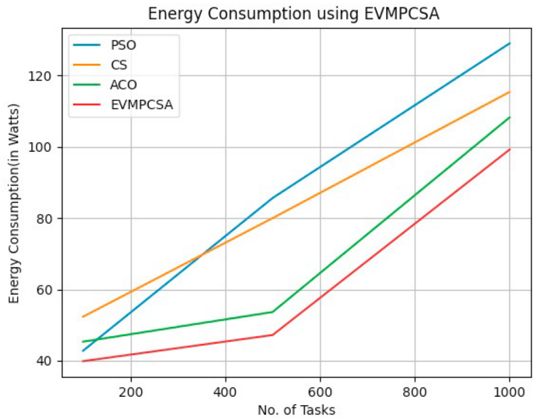

Fig. 3: Calculation of Energy Consumption using EVMPCSA

6. Conclusion and Future Work

VM, server consolidation in cloud computing is still huge challenge as tasks coming onto cloud console are highly dynamic.Therefore, an appropriate VM Consolidation mechanism is needed to consolidate VMs onto a Physical host. For this to happen, we have defined rules for utilization of CPU which is an integrated component in Resource manager which gives information about a VM to scheduler whether it is over utilized or under utilized. Our proposed EVMPCSA works based on the status given to the scheduler it can map tasks onto that VM and that corresponding VM can be consolidated into a physical host. In this paper, Chaotic Social spider algorithm was used to address VM Consolidation. All Simulations are carried out on cloudsim toolkit. Parameters addressed in this work are makespan, Energy Consumption. Our proposed EVMPCSA is evaluated aganist PSO,CS,ACO algorithms.When it is compared with PSO,CS and ACO makespan is greatly minimizes by 30.25%, 23.5% and 17.31% respectively and energy consumption is minimized for PSO, CS and ACO by 27.6%, 24.78% and 10.09% respectively. Finally from simulation, it is observed, our proposed EVMPCSA shown great impact over compared approaches. In future, we need to test EVMPCSA with real time workloads and to evaluate this algorithm in openstack environment.

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