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Energy Aware Task Scheduling Using Genetic Algorithm in Cloud Datacentres

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Abstract: **Cloud computing is a sophisticated technology which provides services to the end users within a fraction of time based on pay-as-you-go model. However energy consumption is one of the major concern in cloud computing as large amount of energy is wasted by the data centres hosting cloud applications and the carbon dioxide gas is released into the atmosphere polluting the environment. So pollution needs to be reduced by lowering the energy usage. Therefore, we'd prefer to propose a green computing solution which is not only able to minimize makespan and operational costs however in addition to minimize the environmental pollution. Throughout this paper, we tend to stipulate a framework that specifies energy minimization is a generalization of makespan minimization by using the Energy-Aware Genetic Algorithm Based Task Scheduling Algorithm. During this paper we tried to conduct a survey on different scheduling methods of energy minimization in cloud data centres and their limitations and at the end of this paper we provide a green energy-aware task scheduling algorithm using the Genetic algorithm for Cloud computing datacenters.**

Keywords: **Cloud Computing, Energy-Aware, QoS, Genetic Algorithm.**

1. INTRODUCTION

Cloud offers significant benefit to IT companies by relieving them from the necessity in setting up basic hardware and software infrastructures, and thus enabling more focus on innovation and creating business value for their services. Moreover, developers with innovative ideas for new Internet services no longer require large capital outlays in hardware to deploy their service or human expenses to operate it [1]. In cloud, resources and tasks need to be allocated not only to satisfy quality of service (QoS) requirements specified by users via service level agreements (SLAs) but also to reduce makespan and energy consumption. As there are a lot of requests submitted by cloud consumers which are processed by the accessible resources, there exists a need for better and improved scheduling technique for proper allocation of tasks to resources within minimum expenditure of time and energy[5]. Cloud led to the establishment of large data centres that contribute in the energy consumed worldwide and consequently the carbon emission and environmental drawbacks. A study shows that data centres are contributing to a fast growing energy consumption[4] and in 2010 it was approximated to contribute 1.1 to 1.5 percent of the total electricity use [5]. According to the trends the power consumption by data centres grows at 18% rate annually [6]. Energy is reported as the second highest operating cost for data centres in 2007 [3]. Furthermore, the carbon dioxide emission by the IT industry contributes to 2 percent of the global emissions [12]. Data centers are not only expensive but also harmful to the environment.

A recent report [1] stated: ‘‘Cloud computing, the long-held dream of computing as a utility, has the potential to transform a large part of the IT industry, making software even more attractive as a service’’. Until recently, high performance has been the sole concern in data center deployments, and this demand has been fulfilled without paying much attention to energy consumption. According to a report on *“Revolutionizing Data Center Energy Efficiency”*, A typical data center consumes as much energy as 25,000 households. Therefore, we need Energy efficient Cloud computing solutions that can not only minimize operational costs but also reduce the environmental impact. In this Thesis work we compare some prevoiusly used algorithms and tried to propose a new scheduling algorithm, that can efficiently decrease the energy consumption for executing jobs. We provide a green energy aware scheduling algorithm using the Genetic algorithm for Cloud computing datacenters.

2. RELATED WORKS

In [7] the authors proposed a new formulation that shows energy-aware scheduling is a generalization of the minimum makespan scheduling problem. By taking the system graph and program graph as inputs they provided three different algorithms for energy-aware scheduling. The first is a genetic algorithm (Plain GA) that searches for an energy reducing schedule. The second (CA+GA) uses cellular automata (CA) to generate low energy schedules, while using a genetic algorithm to find good rules for the CA. The third (EAH) is a heuristic which gives preference to high-efficiency machines in allocation. They tested the algorithms on well-known program graphs and compared their results with other existing algorithms, which confirms the efficiency of their approach. Their method can be extended to a cost-aware setting with the inclusion of cost factors.

In [8] as there are a lot of requests submitted by cloud consumers which are processed by the accessible resources, there exists a need for better and improved scheduling technique for proper allocation of tasks to resources within minimum expenditure of time and energy. The authors propoesd a genetic algorithm based scheduling approach in which the initial population is generated with advance version of Max Min by which they obtained more optimized results in terms of makespan. They evaluated the performance of the MGA(Modified Genetic Algorithm) and existing algorithm against the sample data and the results showed that the proposed algorithm outperforms the existing algorithms.However the proposed algorithm can also be applied to various QoS constraints like cost of service, energy efficiency, security etc.

In [9] the authors present an energy-aware task consolidation (ETC) technique that minimizes energy consumption by refraining CPU use below a specified peak threshold. This is done by consolidating tasks amongst virtual clusters. Ching-Hsien et al. compared ETC with MaxUtil , the results show that ETC reduces power consumption with 17% improvement over MaxUtil. The data center for VMs in ETC are designed to reside on the same rack where network bandwidth is relatively constant. So it would be better for the VMs to take into account fluctuations in network bandwidth.

In [10] the authors proposed a genetic algorithm to efficiently allocate tasks to virtual machines, which allocates resources based on available resources and the energy consumption of each virtual machine. The evaluation results show that the proposed algorithm gives better results than first-fit decreasing(FFD) and best-fit decreasing(BFD) algorithms.This method needs to be optimized with other algorithms, as well as considering QoS parameters in the cloud environment.

In [11] the authors model their problem as a constraint optimization problem. The goal is to minimize the carbon emissions of the data centers by using renewable energy while satisfying: (1)the request processing time constraint; (2) the total electricity budget in each time slot; (3) the intermittent supply of the renewable resources; (4) the maximal number of servers in each data center. They solve the problem by ingeniously transforming it into an integer linear programming model, and calculate the decision variables using existed method. Experiments show that the scheduler can minimize carbon emissions using renewable resources, while satisfying the constraints mentioned above.

In [12], authors introduced an interval number theory to describe the uncertainty of the computing environment and a scheduling architecture to mitigate the impact of uncertainty on the task scheduling quality for a cloud data center. Based on this architecture, they present a novel scheduling algorithm (PRS1) that dynamically exploits proactive and reactive scheduling methods, for scheduling real-time, aperiodic, independent tasks. To improve energy efficiency, they proposed three strategies to scale up and down the system’s computing resources according to workload to improve resource utilization and to reduce energy consumption for the cloud data center.

In [13], an energy-aware resource allocation heuristic for efficient management of data centres for Cloud computing is presented. The proposed method can improve energy efficiency of the data centre, while delivering the negotiated Quality of Service (QoS). This work provides architectural principles for energy-efficient management of clouds, energy-efficient resource allocation policies and scheduling algorithms. Their method has to sacrifice system performance.

The estimated energy consumption of computers in the U.S. was about 2% out of the total electrical consumption in 2010, which makes IT industry the second largest pollution contributor after aviation [14]. In this paper, the authors proposed a novel approach for scheduling, sharing and migrating Virtual Machines (VMs) for a bag of cloud tasks is designed and developed to reduce energy consumption within certain execution time and high system throughput. This approach is derived from an Enhanced First Fit Decreasing (EFFD) algorithm combined with our VM reuse strategy. Furthermore, a virtual machine migration method is introduced to dynamically monitor the cloud situation for necessary migration. Our simulation results using the open source Cloud Report show that EFFD with our VM reuse strategy could gain a higher resource utilization rate and lower energy consumption than regular Greedy, Round Robin (RR) and FDD without VM reuse.

3. PROBLEM STATEMENT

In cloud computing, service requests have heterogeneous resource demands because some services may be CPU intensive whereas others are I/O-intensive. Cloud resources need to be allocated not only to satisfy Quality of Service (QoS) requirements specified by users via SLAs, but also to reduce energy usage and improve the profits of the service providers. In related works many researchers have used Genetic Algorithm for minimizing makespan however traditional genetic algorithm can be extended to an Improved Genetic Algorithm for not only minimizing makespan but also minimizing energy consumption in cloud data centers .

The main aim of our proposed model is to assign each task to a machine such that all the tasks is completed with minimum possible energy expenditure, this is calculated by the fitness function which is a mapping from each schedule to the energy consumed by it . This can be done by calculating the energy consumption of each virtual machines after the task is allocated to a virtual machines.

The energy consumption can be measured by using the following formulation E_{ij}=$p_i t_i$ where p_i is the power consumption of each task allocated to virtual machines and t_i is the execution time of each application allocated to respective virtual machines .

Assuming the total energy consumed when a task is allocated to a Virtual Machine to be $\tau_{ij} = 20$ Kwh such that if the energy consumed by allocation of task to a virtual machine is less than τ_{ij} then that particular genome in the chromosome is represented by 1 and if the energy consumed is more than τ_{ij} then that particular genome in the chromosome is represented by 0.

3.1 Objective Function:

Suppose application a_i is scheduled to execute on cloud C_j which consists of several virtual machines VM_N, where p_i represents the Power of each VM in Hosts and t_i represents the reservation time of the application for VMs then the energy consumption for execution of $a_j$is given by:

$$E_{ij}=p_i t_i \quad (1)$$

We need to minimize energy consumption in virtual machines when task are allocated to them.

Minimize E(x) = min $(\sum_{i=1}^{M} \sum_{j=1}^{N} E_{ij})$ (2)

s.t. E_{ij} (x) < =τ_{ij}

Constraints:

The constraints are listed as follows:

(1) The application a_i has to be finished before the deadline d_i, otherwise, the schedule is considered to be failed.

(2)Assume $\tau_{ij} = 20\ Kwh$
where τ_{ij} is the minimum energy to be consumed when a task is assigned to a virtual machine.

4. PROPOSED MODEL

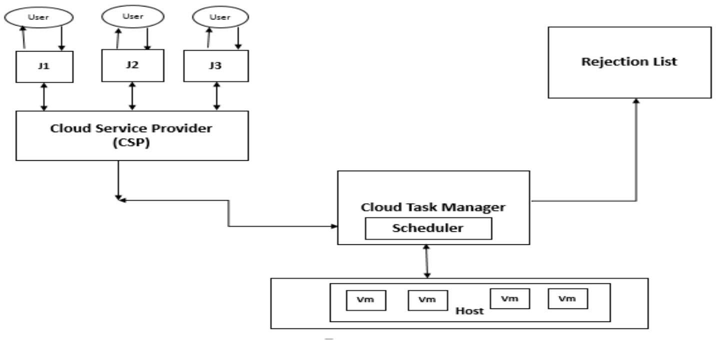

Figure: 1 Proposed Model

5. PROPOSED MODEL OVERVIEW

In the proposed model, when a cloud application is considered as a collection of work items or jobs that carry out a complex computing task by using cloud resources, and the set A= $(a_1)(a_2)$............(a_n) is a batch of applications arrived in a period. During the scheduling process, the client submits a service request for application, a_i (1≤i≤M) with the resource requirements represented as a triplet $(t_{i,}n_i, d_i)$, where, t_i represents the reservation time of the application for virtual machines (VMs), which are the virtualized computing elements in cloud computing by means of virtualization technology, for the number of VMs needed for a_i and d_i for the deadline after what the application will be considered to be failed. The problem need to solve for this algorithm is how to schedule these *M* applications to the given N machines under the constraints and make the objective function optimal. When different cloud users submit their respective requests they are submitted to the cloud service provider and then to the cloud service manager and finally scheduled to the Virtual machines by the help of energy-aware task scheduler which is implemented in cloud service manager.

In the proposed model various components are described as follows:

Cloud Service Provider is responsible for provisioning the requests submitted by the users with different resource preferences. In the next step, the Cloud Service Manager will analyze the resource requirements of each granularity and mapping it on to optimal virtual machines to reach an effective solution.

Cloud Task Manager is responsible for task status management (start, stop, cancel), determining the scheduling sequence and allocating each job to suitable virtual machines under the help of the scheduler.

Process of scheduling algorithm:-

Step 1. Receives a job and its resource requirements such as execution time, number of virtual machines and deadline from the user.

Step 2. All task or requests deposited into CSP (Cloud Service Provider).

Step 3. Calculate Energy value of each job by using the formula E_{ij}=$p_i t_i$.

Step 4. If Energy value greater than the predefined threshold value τ_{ij} it goes to CTM.

Step 5. CTM monitors the jobs and sends all the information to Scheduler.

Step 6 Scheduler schedules the job by checking 2 inequality constraint and arrange them.

Step 7. Scheduler applies Improved Genetic Algorithm and decides appropriate task to be allocated to the Virtual machines in the host.

Step 8. If the task cannot be completed within its deadline it puts the task into reject list.

Energy-aware Task Scheduler is responsible for performing the scheduling algorithm.

For solving any problem there is a need to find a solution for that problem and the solution is found by using the methods and algorithm. The algorithms used for the problem is as follows:

Traditional Genetic Algorithm:

The algorithm has following steps:

Initialization:

Genetic algorithm begins with the initialization of population. Initialization of population is a method in which the set of individuals are defined which represents the possible solution to the scheduling problem. These individuals are known as chromosomes.

In the case of scheduling, each chromosome represents as a sequence of individual schedules for which it uses some form of encoding. In the encoding scheme a chromosome in this Genetic Algorithm consists of genes, each of which stands for energy consumption of a task.

The value of a gene is either 0 or 1 where 0 represents when the energy consumed by task allocation is greater than τ_{ij} and 1 represents when the energy consumed by task allocation is less than τ_{ij}.

Evaluation and Selection:

Each chromosome consists of a fitness value which is evaluated by a fitness function (scheduling goal) and all chromosomes in the population are ranked by these values. Fitness function determines how close actually chromosome is to solving the problem and then the chromosome with the best value will be selected for producing next generation.

Crossover:

It is the process in which two chromosomes mingle their genetic characteristics so that better quality individuals can be produced for next generation, to explore the new solution space which possesses both their characteristics.

Mutation:

Mutation process permits the algorithm to prevent the population of chromosomes from changing into same as one other, for this reason, mutation operators add new attributes in a random way to the genetic search process.

Termination:

After getting optimal solution by using crossover and mutation operators the algorithm stops further iteration when the algorithm reaches the stopping criteria.

Max-min Algorithm:

The minimum completion time set is calculated for each task and that with overall maximum completion time is selected and assigned to a corresponding machine.

This technique finds the task with minimum execution time and assigns them to machine with maximum completion time. Then removes the task from the task set and updates the selected machines and this process continues until the task set is empty and all the tasks are scheduled. Though max min has only been implemented in minimizing execution time we extend it to implement in minimizing energy as Energy is directly proportional to time.

6. CONCLUSION AND FUTURE WORK

In this Thesis work, we described different approaches and present a green energy-aware scheduling algorithm which makes the use of Improved Genetic Algorithm where we propose to merge Genetic algorithm and Max-min scheduling algorithm for successfully executing each and every job individually so that the VMs are selected according to SLA level given by user. Our method can satisfy the minimum resource requirement of a job and prevent the excess expenditure of energy. Hence, we can decrease the energy utilization. The Improved Genetic Algorithm (IGA) technique is used to assign those tasks which consume less energy to the Vms.

Though we have not implemented this approach, so we cannot say it will give best result. In future we want to implement it in software level and try to compare with existing approaches to produce a statistical result. If it will show good result, we will try to implement it in real life also. If it needs we will also adopt new technologies.

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