

**MULTI-OBJECTIVE TASK SCHEDULING IN CLOUD
USING EVOLUTIONARY ALGORITHM AND
ARTIFICIAL NEURAL NETWORK**

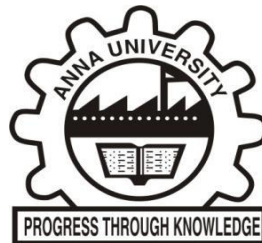
A THESIS

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ABSTRACT

Cloud computing is an Internet centric model that provides dynamic provisioning of hardware, software or services that can be utilized by pay-as-you-go method. As cloud computing eradicates the initial investment cost, the number of cloud users is tremendously increasing. The cloud providers and users can simultaneously receive the economic benefits by efficiently scheduling the tasks and allocating the resources. Hence, workflow scheduling is indispensable to minimize makespan, operating cost and energy consumption for the benefits of cloud users and cloud providers.

The cloud model utilizes the concept of Virtual Machines (VMs), which act as the computational units of the system. Depending on the computational needs of the tasks to be executed, new VMs can be leased and then released later dynamically. The need of number of resources and their characteristics are generally unpredictable in cloud environment. If the resources are properly allocated to all the tasks submitted by users, the execution time can be reduced. However, increasing the number of resources will critically increase the energy consumption. Therefore, resource management and scheduling the tasks are essential in cloud to minimize the operating cost, energy consumption and the makespan.

The different heterogeneous servers may be employed in cloud computing and each server is equipped with several hardware (processing unit, memory unit and network devices). The energy consumption of these servers can be controlled by adjusting the frequency in relation to workloads. The Dynamic Voltage Frequency Scaling (DVFS) technique, which enables the VMs to run at different blends of frequencies and voltages, is used in this research work to reduce the energy consumption. As the energy consumption of a VM is approximately proportional to the square of its frequency, it can be significantly reduced by optimally adjusting the working frequency.

Many research works have been carried out in the last two decades on optimizing the task scheduling for the objectives such as makespan, operating cost, reliability, energy consumption and security. Even though many researchers aimed to minimize

either the working time or the operating cost or the energy consumption of cloud data center, they did not concentrate on reducing them simultaneously. In general, taking efforts on minimizing makespan leads to high energy consumption and operating cost. Hence, it is necessary to obtain the non-domination solutions for these multiple and conflicting objectives by using a multi-objective optimization technique.

Quantum behaved Particle Swarm Optimization (QPSO), Vector Evaluated Particle Swarm Optimization (VEPSO) and Non-domination Sorting Genetic Algorithm (NSGA-II) have been adopted to find the optimal solutions of the proposed multi-objective optimization problem. The suitable weights are added to the objective values and the multi-objective optimization problem is solved like a single objective optimization problem in the first two cases. However, finding exact weight factors of each objective function is practically not possible. Hence, NSGA II, which finds a set of non-domination solutions rather than a single solution, is employed in this research work to find the non-domination solutions for the conflicting multi-objectives.

The proposed concepts have been initially applied to the cloud service consisting of limited number of tasks and resources in order to abridge and investigate the proposed approaches. A cloud service consisting of ten tasks and fifteen resources has been considered in the initial investigation. The Matlab code is used to define the user requirements (tasks and subtasks) and to generate the resources that are provided by the cloud providers. Initially, the single objective optimizations are carried out to minimize the makespan and operating cost individually and thus to investigate the efficiency of the proposed optimization method. The numerical results obtained from the single objective optimization problems show that the makespan and operating cost are efficiently minimized by 37.24% and 29.18% respectively by using the proposed method. Subsequently, the non-domination solutions are obtained using NSGA-II and it is found that a wide range of solutions exist the Pareto-optimal front. So, the cloud user and provider are simultaneously benefitted by choosing the more appropriate one based on the other time varying constraints such as priority of the tasks and availability of resources.

Minimizing the makespan and energy consumption have been considered as the dual objectives in the second case. Dynamic voltage frequency scaling system is used to control the energy consumption. The mathematical models are formulated to calculate the objective functions. The numerical results obtained in single objective optimization problem prove that the makespan and energy consumption are efficiently minimized by 37% and 23.8% respectively using the proposed concepts. As the makespan and energy consumption are contradictory objectives, the non-domination solutions are sought. The numerical results are obtained using NSGA-II show that a wide range of solutions are existing in the Pareto optimal set.

The work is extended for the cloud service consisting of a huge number of tasks by using a dynamic load balancer for migrating the virtual machines dynamically. Cloud Analyst tool is used to simulate the proposed concept and Matlab code is used to define the user requirements (tasks and subtasks) and to construct the genetic algorithm based optimization procedure. Machine learning algorithm is employed in the optimization procedure to effectively control the energy consumption and to migrate the respective resources based on the prediction of their future loads. As the performance of Artificial Neural Network (ANN) in identifying the appropriate resources of the cloud service is better than other machine learning algorithms, ANN is used in this research work to predict the more suitable resources during the genetic algorithm based optimization process.

The numerical results are obtained for different number of tasks and the results are compared between the optimization techniques in which DVFS and ANN were optionally used. The results show that the energy consumption is effectively minimized by incorporating the DVFS system in the optimization procedure. However, the makespan is critically increased, as DVFS mainly concerns in reducing the energy consumption. Hence, the optimization problem is converted as a multi-objective optimization problem and the non-domination solutions are obtained using NSGA-II with the support of ANN and without the support of ANN.

The results obtained in single objective and multi-objective optimization problems show that the optimization procedure constructed with ANN finds out better solutions than the optimization procedure constructed without ANN, as ANN predicts the most appropriate resources based on the forecasted completion time and energy consumption. In general, the computational complexity of genetic algorithm highly increases with the number of generations and population size. However, it is proved in this work that the number of generation shall be critically reduced by using ANN in the optimization procedure. Further, the computational cost is also minimized by optimally choosing the control parameters of GA like number of generations, population size, crossover probability and mutation probability.