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# Solving Task Scheduling Problem in the Cloud Using a Hybrid Particle Swarm Optimization Approach

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## ABSTRACT

Synergistic confluence of pervasive sensing, computing, and networking is generating heterogeneous data at unprecedented scale and complexity. Cloud computing has emerged in the last two decades as a unique storage and computing resource to support a diverse assortment of applications. Numerous organizations are migrating to the cloud to store and process their information. When the cloud infrastructures and resources are insufficient to satisfy end-users requests, scheduling mechanisms are required. Task scheduling, especially in a distributed and heterogeneous system, is an NP-hard problem since various task parameters must be considered for an appropriate scheduling. In this paper, the authors propose a hybrid PSO and extremal optimization-based approach to resolve task scheduling in the cloud. The algorithm optimizes makespan which is an important criterion to schedule a number of tasks on different virtual machines. Experiments on synthetic and real-life workloads show the capability of the method to successfully schedule tasks and outperforms many state-of-the-art methods.

## KEYWORDS

Cloud Computing, Extremal Optimization (EO), Makespan, Meta-Heuristic Algorithm, Particle Swarm Optimization (PSO), Task Scheduling

## INTRODUCTION

The notion of cloud computing has evolved as an innovative computing platform, but a close examination of the paradigm, reveals it is a collection of off the shelf components loosely connected together. The notion of the cloud is really the integration of applications delivered as a service over existing cyber infrastructure such as the Internet. These infrastructure networks have joined food, water, transportation, and energy as critical resources for the functioning of the global economy. As an on demand digital ecosystem that provides massive storage and computing resources, allowing customers to consume resources utilizing flexible pricing or pay-as-you-go model.

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Cloud computing has revolutionized the way software and hardware resources are acquired and used in every sector. Every company in every sector now looks to the cloud as the means for storing and processing their data and as the means for running their applications. Cloud providers stand up data centers running state-of-the-art processors (e.g., GPUs and FPGAs), storage, and networking, and state-of-the-art services (e.g., machine learning algorithms and models). These resources benefit customers of cloud providers. As more and more companies make their internal processes and external businesses increasingly data-driven, the demand for cloud capability will continue to grow.

Currently the three most common cloud computing service models which each satisfy a unique set of requirements. These three models are known as Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). These models are generally deployed in the following manner, public, private, community and hybrid. Each model has its own benefits and detriments.

First, IaaS is a type of cloud that provides access to an infrastructure. This means leasing servers (virtual or not) and the underlying infrastructure such as storage. Second, SaaS cloud is a distribution model in which a provider hosts the applications and makes them available to his customers via remote access. Services such as Gmail that allows remote access to an e-mail management application and a SurveyMonkey that allows access to a distribution application and analysis of polls directly on the internet are considered as SaaS clouds. Finally, PaaS allows the user to have access to frameworks and tools to develop and deploy applications quickly and efficiently. Microsoft Windows Azure and RedHat OpenShift are examples of PaaS. The Cloud computing environment is needed to meet the computational demands of diverse end-user tasks. When server's resources are insufficient to satisfy user requests, scheduling mechanisms become a major challenge for the cloud. In general, task scheduling is the process of assigning tasks to available resources based on task characteristics and constraints. In cloud environment, an additional complexity arises from the fact that cloud servers are heterogeneous multiprocessing systems. Scheduling can be done at three levels i.e. service level, task level and virtual machine level (Singh & Chana, 2016). Tasks and their target resources in a cloud environment can be chosen using various strategies and algorithms. Given a collection of tasks, a collection of resources upon which these tasks are to execute, scheduling algorithms and resource selection find out whether these tasks can be mapped onto the available resources. Resource allocation strategy can be random, round Robin, or greedy (in resource processing capacity and waiting time) or their hybridization. Task scheduling can be based on FCFS (First Come First served), SJF (Short Job First), priority, or by task grouping. Each algorithm/strategy has its pros and cons. Hybrid approaches can be used to come up with a better solution that tries to minimize the disadvantages of the basic algorithms. Scheduling result is a deployment plan that is an allocation of end-user tasks among the various provider's resources. The user expects his tasks to be performed within a minimum execution time with better quality of services (QoS). However, the provider wants that his available resources should be optimally utilized to have better cost benefits. The problem of task scheduling is a combinatorial optimization problem, where it is not possible to find an optimal global solution by using simple algorithms or rules. It is well known as a NP-complete problem (Ullman, 1975). As a result, an exhaustive enumeration to find the optimal solution is mostly impossible. Heuristic algorithms are good candidates to solve this problem. Among these algorithms, we can cite taboo search, particle swarm optimization, simulated annealing and genetic algorithms, etc. In this paper, a heuristic scheduler is developed based on the hybridization of particle swarm optimization and extremal optimization to reduce makespan and improve load balancing. The major contributions of this paper are:

- Hybridization of the PSO and EO algorithms to minimize task execution time and to improve resource utilization in the cloud. The heterogeneity of the cloud resources is modeled by assuming different computing times for the same task on different processors and different physical characteristics of cloud hosts and virtual machines.

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