

A Conceptual Framework For Multi-Objective Task Scheduling In Cloud Environment

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Abstract- Cloud computing is a dominant model which provides many computing services via internet. Cloud performance can be optimized by using efficient task scheduling models which determine how the available virtualized resources are mapped with the user tasks. There are many traditional scheduling algorithms which emphasize on single objective such as load balancing or resource utilization. Now the cloud environment needs multi objective optimization which includes many parameters like cost, quality of service, resource utilization, energy consumption etc. This paper explains a conceptual framework for a multi objective task scheduling in cloud environment. Thus proposed framework focuses on objectives like minimization of makespan, reduces the execution cost, increases the resource utilization and minimization of energy consumption.

Keywords- Cloud Computing, Multi-objective, metaheuristic

I. INTRODUCTION

Cloud computing help the organizations and individual users to use many computing services like storage, infrastructure, scalable computing in a pay-per-usage model. Most of the time cloud resources are not utilized properly because of inefficient scheduling algorithms used in the data center[1]. Task scheduling plays a vital role in ensuring optimal utilization of resources, high performance and quality of service. The data centers are heterogeneous, dynamic and multi-tenant which makes the task scheduling very complex. An effective task scheduling should meet the users needs and also improves the efficiency of the cloud system [2]. The proposed framework uses various optimization algorithms like Ant Colony Optimization(ACO), Genetic Algorithm(GA) and Particle Swarm Optimization(PSO).

This framework defines many components like job analyser, objective examiner, resource manager and quick decision engine. It also includes the interaction of these components with the scheduling process. An optimum solution is predicted by many learning-based techniques which uses machine learning models based on data patterns and performance[3]. This framework offers an organized basis for recognizing, categorizing and ranking goals. The goal of the

framework is to direct the development of more intelligent and adaptive scheduling algorithms by abstracting the interactions between cloud entities including tasks, virtual machines(VMs), hosts and brokers. This model does not focus on implementation specifics and it lays a theoretical ground work for future algorithmic advancements and empirical verification.

II. PROPOSED CONCEPTUAL FRAMEWORK

The proposed conceptual framework focuses on a multi-objective task scheduling which includes makespan, execution cost, energy efficiency and resource utilization in a cloud environment. It is done by using a variety of heuristic and metaheuristic scheduling algorithms.

A.Overview

The proposed system works in data centers. Each data center should execute multiple user tasks which are called cloudlets. The data centers contain multiple virtual machines(VMs) which are hosted on physical servers[6]. The life cycle of each task can be represented as structured flow which starts from submission, the execution and finally completion. An optimal mapping is done between the tasks and VMs by a multi objective scheduler. The performance metrics is calculated using a fitness evaluation models.

B. Framework Architecture

It includes five layers

1. User Interactive Layer : In this layer the input parameters are taken like length of the task, priority if any, size of the data etc. The user submits the task by specifying the quality of service requirements.
2. Job Management Layer : This layer monitors the execution order and controls the job queues. Pre processing of job is done in this layer which includes classification, grouping and prioritization.
3. Resource Management Layer : This layer is responsible for VM creation, deallocation of task on the basis of world load demand. A list of available

physical and virtual resources is maintained by this layer. The scheduler obtain real-time data from this layer.

4. Multi-objective Layer : This is the core layer of this framework where multiple objectives are maintained and optimized[5].

- Maximizing Resource Utilization(R_c)
- Minimizing Makespan(M_T)
- Minimizing Energy consumption(E_c)
- Minimizing Execution Cost(C_E)

Using a fitness function these objectives are evaluated mathematically. The optimal mappings is established by using metaheuristic algorithms like Genetic Algorithm(GA), Ant Colony Optimization(ACO) and Particle Swarm Optimization(PSO).

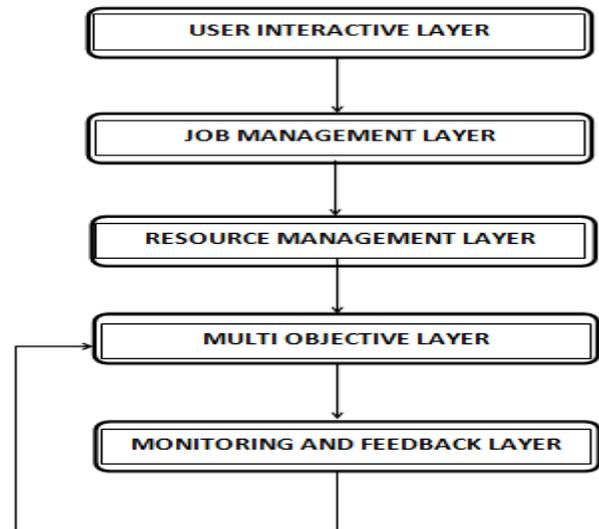
5. Monitoring and feedback Layer : This layer adjusts the allocation strategies by updating the scheduler with real time data[7]. The system performance is monitored during run time.

C Functional Flow

Within the framework the flow of operations can be categorized as follows:

- Step 1: The user submits the job and its quality service requirements.
- Step 2 : The information on available resources is collected by the system from the resource management layer.
- Step 3 : The task to VM mapping is generated by the multi-objective scheduler using the chosen metaheuristic algorithm[8].
- Step 4 : The mappings are evaluated using multi-objective fitness function.
- Step 5: The task assigned to each VM is executed.
- Step 6 : The feed back is taken for future scheduling strategies.

D. Conceptual Representation



III. MATHEMATICAL MODELLING OF OBJECTIVES AND FITNESS FUNCTION

Various optimization procedures are applied by the task schedulers to allocate task among VMs and to achieve optimal resource utilization [4]. In this section a fitness function is created to define the mathematical models of all the objectives.

A Notations Used

Symbol Description

- (J_x) Job (x) submitted to the scheduler
- (VM_y) Virtual Machine (y) available in the data center
- ($T_{\{xy\}}$) Expected execution time of job (j_x) on (VM_y)
- ($C_{\{xy\}}$) Cost of executing (J_x) on (VM_y)
- (m) Total number of tasks
- (n) Total number of virtual machines
- (S_y) Processing speed of VM_y in MIPS
- (L_x) Length of task (T_x)
- (E_y) Energy consumed by (VM_y) during execution
- (R_y) Utilization rate of (VM_y)
- (w_z) Weight assigned to objective (z)

B.Objective 1: Maximization of Resource Utilization

Resource utilization means how the available computing power is used.

So function $U = \frac{\sum_{x=1}^m \frac{L_x}{S_y}}{n \times \text{Makespan}}$ 1 is

This can be rewritten as
 Min F3=(1-R)

C.Objective 2: Minimization of Makespan

Makespan is the total time required to complete the execution of all submitted tasks[9].

$$\min F = w_1 \times \frac{F_1}{F_1^{\max}} + w_2 \times \frac{F_2}{F_2^{\max}} + w_3 \times \frac{F_3}{F_3^{\max}} + w_4 \times \frac{F_4}{F_4^{\max}}$$

$$\text{Makespan} = \max_{x \in m} (CJ_x)$$

Where CJ_x is the completion time of job x.

$$CJ_x = SJ_x + EJ_{xy}$$

SJ_x is the start time of job x

$$EJ_{xy} = \frac{L_x}{S_y}$$

So function 2 is

Min F1=Makespan

D.Objective 3: Minimization of Energy Consumption

$$E_y = B_{idle} + (B_{max} - B_{idle}) \times R_y$$

Where B_{idle}=Power consumed when host is idle.

B_{max}=Power consumed at maximum utilization

R_y=Utilization of host y

Total energy consumption of all host

$$D_{total} = \sum_{y=1}^n D_y \times J_{active,y}$$

So function 3 is

Min F4=D_{total}

E.Objective 4: Minimization of Execution Cost

Execution cost depends on the amount of resources used and the time duration.

$$C_{xy} = (S_y \times J_{xy}) \times A_y$$

Where A_y is the cost rate per unit time for VM_y.

So function 4 is

$$\min F^2 = \sum_{x=1}^m \sum_{y=1}^n r_{xy} \times C_{xy}$$

Where r_{xy}=1, if task J_x is assigned to VM_y, 0 otherwise

F.Fitness Function

A weighted sum model is calculated to find the fitness function.

Where w₁+w₂+w₃+w₄=1

IV. CONCLUSION AND FUTURE ENHANCEMENTS

A. Conclusion

This paper presents a conceptual framework for multi-objective task scheduling in cloud data centers. The framework is designed to solve the key challenges of cloud computing task management, like optimization of conflicting objectives. The model simultaneously targets makespan minimization, cost reduction, energy efficiency, and resource utilization. By using meta-heuristic optimization, the framework can adapt to large-scale cloud environments with dynamically varying workloads. Decision-makers can adjust objective weights according to organizational priorities, such as cost efficiency, energy conservation, or throughput improvement.

B. Future Enhancements

The conceptual framework provides a foundation for future research and practical implementation. This framework can be implemented in CloudSim Plus. Validate the framework experimentally using simulated cloud environments. This framework can be compared with other meta-heuristics algorithms like Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), and Firefly Algorithm. It can incorporate real-time workload monitoring to adjust objective weights dynamically for better adaptability.

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