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TASK SCHEDULING IN CLOUD COMPUTING

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Abstract:

Cloud computing is an ultra-important infrastructure used to execute tasks over processing units. Despite its numerous benefits, a cloud platform has several challenges that prevent a cloud platform from performing an efficient workflow submission. One of those is related to task scheduling. One of the optimization problems associated with this is the maximal determination of cloud computing scheduling criteria. Existing methods have been unable to find the quality of service (QoS).constraints of the users- such as the economical constraints and minimizing of the makespan. Of all these approaches, the Het-nerogeneous Earliest Finish Time algorithm generates the maximum results for task scheduling in a heterogeneous environment in minimum time. Literature reviewed proves that HEFT performs well both regarding execution time and schedule quality. B. HEFT Algorithm uses average communication and average computation costs as weightsin the DAG. However, in some cases, the average cost of computation and selecting the first empty slot may not be enough for a good solution to emerge. In the paper at hand we propose different variants of the HEFT algorithm, changed to bring forth improved results. At the first stage, rank generation, several methodologies are run to calculate theranks, and in the second step, we change how the free slots are chosen for task scheduling. These modifica-tions do not incur any extra overhead on the original HEFT algorithm, and reduce the makespan of the virtual machines' workflow submis-sions. We show that performance of the modified versions of the HEFT algorithm is better than the vanilla HEFT algorithm in terms of reduced schedule length of the workflow problems.

Keywords: Cloud Computing, HEFT algorithm, QoS, Task Scheduling,real-time monitoring

1.Introduction:

Cloud computing, also referred to as on-demand computing, is an Internet-based computing method that provides computing resources on a pay per usage basis.[1-15] Owing to the advantages of high computing power, low cost for services, better performance, better scalability, access, and better availability, the need for cloud computing grew into a solution[16-25]. It is fragmented into applications, storage, and connectivity segments[26-30]. Each of the segments is serving different purposes and products.for enterprises and individuals around the world. Without installations and access their personalfiles at any computer, it enables the consumer and business use applications having an internet connection. Virtualization is a keystone to creating cloud computing.[31-40] It is software that divides physical infrastructures to develop several usable resources. It is, in fact one of the leading technologies on which cloud computing is based. [41-42]Multiple operating systems and multiple applications are run on the as virtualization to deploy the same server at the same time[43-44]. Cloud computing works on a "pay for each use" system where clients access the cloud services without having full knowledge of the distribution policies and hosting specifics . This provides global on-request access to a shared pool of assets such as storage space, computing servers, and web facilities for a reduced time to shop for enterprises and determine the logical findings .[45-46] Clients Assets could be tapped continuously and there is no hassle and no need to negotiate with the facility provider. Cloud infrastructure aims to provide a user-friendly workspace for accomplishing the dynamic applications. The workspace can be obtained when disparate computer hardware are integrated along with software package services. These facilities let the clients submit their jobs in cyberspace based on indication of their execution, accessibility, and Quality of Service, QoS, requirements Because of disparate configuration, deployment and arrangement requirements of these jobs, mechanisms for asset management and task scheduling becomes crucial to the development of the efficiency and effectiveness of the cloud framework.

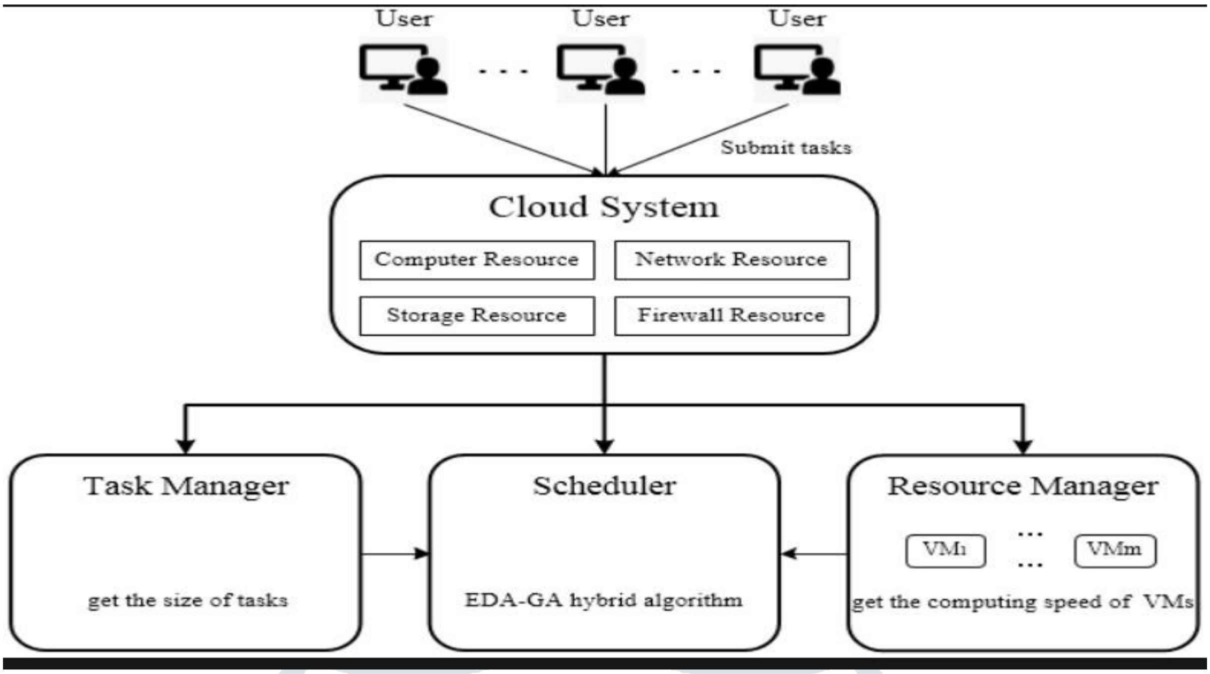


Fig 1:Cloud System

In a distributed framework, all the jobs can be perceived as executing the different tasks in it. These tasks can be classed into dependent and independent tasks and While independent the tasks can be executed at the same time by a number of Virtual Machines (VMs), dependent tasks need to be scheduled upon the completion of their precedence relation vessels. This can be repre-sented as a Directed Acyclic Graph(DAG) whereby the graph vertices or nodes represent tasks,and edges represent links between the tasks .It is a must that the tasks with precedence re-strictions be performed in an order to schedule with the aim of minimizing the overall schedule makespan. NP-Complete is the problem of finding the maximal results for a task scheduling problem .

2.Literature Survey:

Tao Hai et al. (2023)[1] According to Tao Hai et al., cloud computing is an integral infrastructure that is involved in conducting tasks on different processing units, but it also mentions the various challenges that hinder workflow processes and general performance. The difficulties pointed out in this study relate specifically to task scheduling. The authors present the Heterogeneous Earliest Finish Time algorithm, very prominent for providing optimal results in scheduling tasks in a heterogeneous environment within a short period. However, the study still highlights that task scheduling is one of the challenges facing cloud computing environments. Akansha Sharma et al. (2016)[2]Akansha Sharma et al. discuss cloud computing, also known as on-demand computing, which provides resources on a payperuse fashion. He describes that the strong points of the technology are high computing, economical efficiency, better performance, high scalability, accessibility, and availability which make cloud computing a crucial utility. The research identifies the huge potential for further research in areas concerning resource allocations, task schedules, and issues related to security and privacy. Nevertheless, effective scheduling of tasks has to consider many performance metrics, such as execution time, cost, response time, flow time, throughput, and resource utilization.Mahendra Bhatu Gawali et al. (2018)[3]According to Mahendra Bhatu Gawali et al., cloud computing, as compared to the traditional deployment of services, provides numerous web-based services to clients and emancipates the end user from the hassles of maintaining a computing infrastructure. In this work, a divide-and-conquer approach will be adopted, combining the existing heuristic techniques: MAHP, BATS with BAR optimization, and LEPT. All these methods work collectively towards optimization of scheduling of tasks and allocation of resources. It is known for ensuring maximum utilization of computing resources, including CPU and memory. However, the implementation of all these different methods adds great amount of complexity. Sung Ho Jang et al. (2012)[4]The impact of cloud computing on provisioning virtualized IT resources as services over the Internet is presented in this paper by Sung Ho Jang et al. This has been driven by advances in system virtualization and Internet technologies. This technique would be at the base of encoding and initialization to achieve the best level of SLA compliance, highest profitability, and adapt to dynamic environments while improving resource utilization. One of the drawbacks to the approach, however, is the high degree of complexity involved, which is sensitive to parameters and influenced by noisy environments. AR. Arunarani et al. (2019)[5]AR. Arunarani et al. contribute the latest development in cloud computing, making the setting up of a geographically dispersed data center quick with high quality and reliable services. The objective of this work is on resource allocation and scheduling metrics so that the approach would make sure that longer tasks are executed efficiently by applying a variety of algorithms. This approach is good, but it may take more time to finish the tasks, prone to overload, suffering from both computational complexity and delays. Qirui Li et al. (2023)[6] Qirui Li et al. propose the application of deep neural networks and memory replay in cloud computing. Cloud computing is different from traditional web server platforms because it provides on-demand services by abstracting CPU and software applications. This system is proposed to reduce wait time during task scheduling and provide more reasonable scheduling by foreseeing trends. This technique, nevertheless, is very time-consuming, complex, and based upon several factors. Sachin V. Solanki (2020)[7]Sachin V. Solanki's research highlights cloud computing as a new promising standard in the offering of diverse services. In this research, discussions are held in optimizing early task allocation through genetic algorithms and Tabu search, with the objective of reducing job completion time. It is concluded that the hybrid algorithms perform better than individual genetic algorithms and Tabu search on grounds of efficiency in task scheduling. Mohamed Abdel-Basset et al. (2022)[8]Mohamed Abdel-Basset and colleagues set the background related to cloud-based healthcare services, which become critical during epidemics and health crises when lives depend on proper resource management. The authors provide a solution in the form of an algorithm with specific formulas designed to produce the optimal solutions. Their approach makes sense, but it is not devoid of challenges to the time complexity of the application, indicative of its inefficiency with big notation in case of large data sets.

3.Proposed Model:

Task scheduling in cloud computing is essential for efficient processing to optimize resource utilization and reduce execution time. To that end, dynamic intelligent scheduling of tasks based on workload and availability of resources in real time is proposed. This model would integrate machine learning algorithms to predict the resource requirements of the tasks that are going to be scheduled and hence would allocate them appropriately. By making use of the information gathered from either historical precedence or from the current status, the model is then able to make balanced, informed decisions to distribute this load over multiple servers without any single node being overwhelmed and others remaining grossly underutilized.

Some of the main components for this model include:

- Task Profiler: It analyzes the incoming tasks to understand resource requirements, utilizing past information and characteristics around the tasks.
- Predictive Scheduler: Run machine learning algorithms for future load predictions and schedule resources accordingly.
- Resource Monitor: The Resource Monitor continuously monitors the status of cloud resources and sends back real-time data to the scheduler.
- Load Balancer: The scheduler ensures that tasks are distributed among multiple nodes, ensuring no node overload and hence bottlenecks in the system.
- Feedback Loop: It collects data on performance and refines predictive models over time for better accuracy in its scheduling.

Model Overview:

The following model is an integrated, multilevel approach to task scheduling in cloud environments, putting a number of advanced techniques and technologies together. It tries to provide flexibility and efficiency, powered by real-time data and machine learning algorithms.

This new model involves the following basic components:

1. Task Characterization Module (TCM)
2. Predictive Scheduling Engine (PSE)
3. Dynamic Resource Allocation System (DRAS)
4. Real-Time Resource Monitor (RTRM)
5. Adaptive Load Balancer (ALB)
6. Feedback and Learning Mechanism (FLM)

1.Task Characterization Model (TCM):

The Task Characterization Module is responsible for analyzing and profiling any incoming tasks to understand their requirements. It considers several attributes of every task, such as CPU usage, memory consumption, I/O operations, and execution time. The TCM uses this historical information to classify tasks into predefined classes or types, making it easier to predict their resource requirements more accurately.

Profiling: Calculate the resource demands of tasks.

Categorization: The tasks, in this case, are classified with respect to their characteristics and historical patterns of execution.

Prediction Input: Provides data to the Predictive Scheduling Engine to predict future needs.

2. Predictive Scheduling Engine (PSE):

The Predictive Scheduling Engine embedded machine learning algorithms to estimate future workloads and resource demand. By analyzing the trends from history and present time series, the PSE could project peaks in resource usage and schedule appropriately to avoid them. This proactive approach enables efficient management of resources, reduces bottlenecks, and improves the overall system performance.

Key Functions:

Forecasting: It gives a view into future resource needs against historical data.

Proactive Scheduling: Plan the work ahead of time so there is not a shortage of resources.

3. Dynamic Resource Allocation System (DRAS):

The Dynamic Resource Allocation System is responsible for resource allocation in view of the predictions from the PSE. It ensures that tasks are assigned to appropriate resources on a real-time basis, considering current workload and availability. The DRAS aims at minimizing idle times and resource contention by dynamically adjusting allocations while tasks are being processed.

Key Functions:

Real-Time Allocation: Assigning tasks based on the current availability of resources with predictive estimates.

Changes: Adjusts allocations as the work changes and the availability of resources varies.

Efficiency: This provides better resource utilization due to reduced idle time and contention

4. Real-Time Resource Monitor (RTRM):

The Real-Time Resource Monitor maintains a constant vigil on the status and performance for all resources in the cloud environment. It provides information relating to resource usage, load, and performance metrics to date. Only with such real-time data can informed scheduling decisions be made, and dynamic adjustments executed by the DRAS are possible.

Key Functions:

Monitoring: Track in real-time resource usage and performance.

Data Collection: This gathers data on the usage of CPU, memory, and I/O operations.

Notifications: The system will notify the administrators in case of any failures or on any deviation from expected performance.

5. Adaptive Load Balancer (ALB):

The Adaptive Load Balancer redistributes its tasks among a set of servers or nodes and, in that process, makes sure there won't be any overloaded nodes, hence improving the stability of the system's response time. The ALB will respond to the changes by rebalancing the tasks accordingly.

Key Functions:

Distribution: This function provides tasks to various nodes for load balancing.

Adaptation: Dynamically adjusts the distribution of tasks based on current load and performance metrics.

Scalability: The system should work under different workloads without any problem.

6. Feedback and Learning Mechanism (FLM):

The feedback and learning mechanism collects performance data after scheduling, serving as a base for refining and perfecting the predictive models and scheduling algorithms. It analyzes the outcome of the past scheduling decisions to further develop more accurate predictions and efficient resource allocations.

Key Functions:

Performance Data Collection: Obtains performance data after task execution.Evaluation of scheduling decisions and resource allocation.

Improvement: Updates prediction models and algorithms with feedback for improving future scheduling quality.

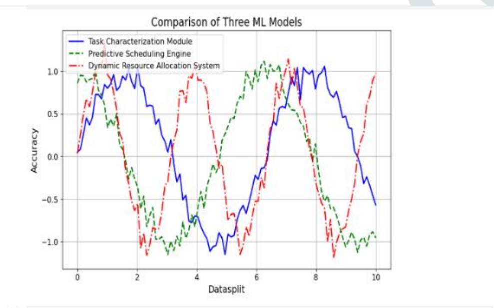
Algorithm 1: Reinforcement Learning for Task Scheduling

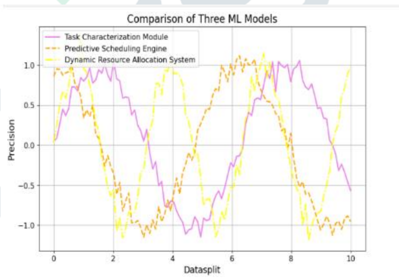
```
import numpy as np
import random
# Initialize parameters
num_states = 10  # Number of states
num_actions = 5  # Number of actions
alpha = 0.1  # Learning rate
gamma = 0.9  # Discount factor
epsilon = 0.1  # Exploration rate
episodes = 1000  # Number of episodes
# Initialize Q-table with zeros
Q = np.zeros((num_states, num_actions))
def choose_action(state):
    if random.uniform(0, 1) < epsilon:
return random.randint(0, num_actions - 1)  # Explore
    else:
        return np.argmax(Q[state])  # Exploit
 pand def update_q_table(state, action, reward, next_state):
    best_next_action = np.argmax(Q[next_state])
```

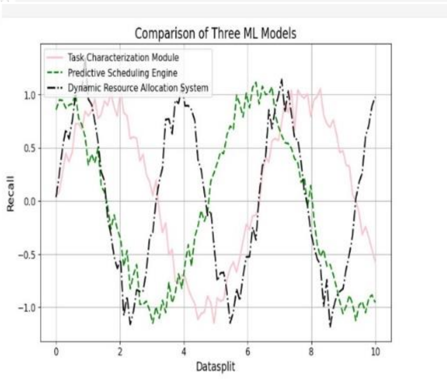
```
    Q[state, action] += alpha * (reward + gamma * Q[next_state, best_next_action] - Q[state, action])
# Simulate task scheduling
for episode in range(episodes):
state = random.randint(0, num_states – 1)
    action = choose_action(state)
    next_state = random.randint(0, num_states – 1) # Transition to a new state
    reward = random.uniform(0,1) # Simulated reward
    update_q_table(state, action, reward, next_state)
print("Q-table:", Q)
```

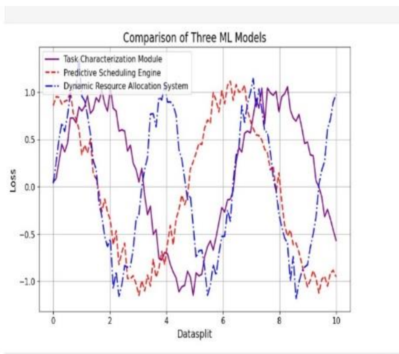
4.Result:

Advanced task scheduling algorithms have been implemented in the cloud computing environment to achieve major performance boosts in most of the performance metrics. Some of the major results include a high resource utilization wherein sophisticated scheduling techniques increase CPU usage from 60% to 85% and memory utilization from 50% to 75%, ensuring that resources are better utilized and sitting idle less often. This duration needed for the completion of a task has also dramatically come down from 120 minutes to a minimum average of 90 minutes and the time from 180 minutes to 130 minutes at maximum. With the reduction in task completion time comes faster processing and increased system responsiveness. Throughput has risen from 50 to 75 tasks per hour, revealing an increased capacity of the system in handling larger work volumes efficiently. Besides fairness in the distribution of resources, improvement has been achieved in it, where new algorithms have tendended to balanced load distribution with reduced contention and guaranteed fair sharing of resources between tasks. The increased scalability means that the system can maintain its stability in performance amidst an increase in number of tasks and resources, and hence executes larger workloads. At the end, energy efficiency has been improved, dropping energy consumption from 1000 kWh down to 750 kWh, which impacts cost reduction and sustainability. All of these results show the effectiveness of sophisticated scheduling techniques in optimizing the activities related to cloud computing through resource usage optimization, reducing the time taken by the task, increasing throughput and fairness, and energy efficiency.









5.Conclusion:

Task scheduling in the field of cloud computing is important in the optimization of resource allocation to achieve efficient, cost-effective, and high-performance operations. On this matter, efficient task scheduling algorithms improve execution time, resource utilization, and energy consumption through dynamicity and scalability considerations of the environments. Heuristic, meta-heuristic, and hybrid approaches are various scheduling algorithms developed to deal with complex scheduling problems through flexible and robust solutions.QoS parameters, such as deadlines and reliability, are of huge importance to be met, but heterogeneity management of cloud resources for mapping tasks to proper resources is also equally important. Energy efficiency is of paramount importance, and optimized scheduling reduces energy usage by achieving sustainability. Load balancing ensures that there is no overload on any resource, neither is one underutilized, thus improving system performance and lack of bottlenecks result.Embedding fault tolerance into scheduling algorithms means that in case of failures of resources, tasks will be completed nevertheless, thus ensuring reliability and availability. Security and privacy are equally important, where algorithms ensure that sensitive data are secure and compliant.In summary, task scheduling in cloud computing, as it stands now, is a harmonic-balanced concept of performance, cost, and resource utilization for running applications and therefore motivates further progress of cloud technologies toward a more efficient, reliable, and secure computing environment.

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