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RESEARCH ARTICLE

Cloud Based Multi-Robot Task Scheduling Using PMW Algorithm

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ABSTRACT Scheduling of robots is one of the imperative assignment in a multi robot system. Scheduling is prerequisite when there is a multiple task need to be assigned to multi robot in an arranged manner. There is a growing need for robots to perform complex tasks autonomously. Multi-robot environment becomes complex as there are multiple factors need to be addressed simultaneously which require fast computation and more space. Using cloud computing platform could be one of the optimal solution for this problem. This paper presents the use of cloud computing platform for implementing the proposed Periodic Min-Max Algorithm (PMW) for multi robot task scheduling. Amazon web service (AWS) platform is utilized for deploying the algorithm for multi robot task scheduling. The task performed by the robots is considered as a single service in context with cloud platform and it withdraw an advantage when the number of services increases with time. Time requirement to complete the task and the load balancing parameter are analysed using the proposed approach and is compared with other relevant work. The results presented in the paper clearly shows the performance improvement in both the parameters. There is an improvement of about 3-7% in both the parameters and are reported in the paper. The paper also emphasize on the deployment of cloud computing platform for the service robots. Time completion factor is analysed and reported in the paper to proof the advantage of using cloud platform for the service robots. The novel way of using the algorithm with cloud server seeks many advantage are also observed, analysed and presented in the paper.

INDEX TERMS AWS, load balancing, cloud computing, PMW, multi-robot, scheduling.

I. INTRODUCTION

The advent of new technologies landing day by day has pushed the limits of automation to be more scaled-up and efficient, robots are playing a pivotal role in this system. Service robots becomes more complex when they are bound to work in groups, single robots require a certain specific parameter to be taken care of, while multi-robot system requires consideration of multiple factors like coordination of robots, scheduling of task among, robot's average performance of all the robots and many more other factors [1], [2]. To satisfy more than one parameter at the same time makes

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the approach more complex and difficult. But this is the only way to increase the utilization of service robots to its optimum level. Dealing with such high complexity and providing solutions to it helps the system to make it more effective and more accurate. Multi-robot task allocation is often formulated as a multiple traveling salesman problem, a variant of the NP-hard traveling salesman problem (TSP) [3], [4], for which the branch and bound paradigm is commonly used to generate optimal solutions. There are sufficient literature's which treats the same problem in many other ways and provide the solutions. In the current time, there is no unified multi-robot system definition. Most of them are usually defined as dynamic or composed of several members for completing one or more tasks through certain communication methods or cooperation mechanisms [5]. Designing a multi-functional robot is a complex project, but designing a multi-robot system, consisting of multiple limited-function robots to accomplish the same task, is relatively affordable.

This paper attempts to address the issue of scheduling of multiple robots for task allocation. The time based comparison of different approach with that of the proposed approach is also presented in the paper. Here, in this section the focus is on the preliminary part of the problem formulation. The most important aspect of the multi robot system is to coordinate the robot in such a way so that they should not get collide during the execution and performs smoothly and effectively [6], [7]. To ensure this, it is required that the coordination mechanism should be effectively implemented. Primarily all the robots are required to start from its source coordinates, afterwards they are required to follow a certain derived path, and then the robots are required to traverse through that path and approach towards the destination. It is also mandatory required that while traversing the path the robot should not collide with any obstacle present in the path and also must avoid other robots traversing for their path. This is mainly the task of coordination mechanism used in the system. There are several ways to coordinate the multi-robot system like centralized coordination mechanism, decentralized coordination, hybrid approaches and many more ways are there [8]. Here in our work we have used the centralized mechanism to coordinate the robot to avoid any collision while execution [9], [10], [11]. The destination based smart approach is used to find out the optimum path between the source and destination. Robots are made to follow coordinates received after the outcome of this smart distance based approach [12].

After ensuring the coordination of robots, the next step is to schedule the robots. The scheduling policy for the robots is accomplished using the cloud server. First of all the tasks are identified and they are segregated by identifying the nature of each tasks, the nature of tasks are primarily the time required by the respective task to get complete. There are many other factors associated with it while identifying the nature of each tasks, for example if any other resource requirement is there for the task to complete it. But here, we have considered only the time requirement and based on which the scheduling policy is framed [13], [14]. The paper also emphasizes on the usage of cloud computing platform for service robots. Due to the presence of multiple technologies like Artificial intelligence, Deep learning, neural network, fuzzy system and many other hybrid technologies which are applied on the service robot's parameter. Using cloud server for controlling robots and applying the proposed approach significantly improves the performance of parameter. The advantage of having high computation capacity and availability of the past experience makes the overall system more smart and responsive while executing in certain conditions [15].

The rapid growth of virtualization technology attracted cloud computing to solve scientific, business and engineering problems. The performance for the robots are improved by applying the task scheduling techniques. Task scheduling can improve the allocation of shared-resources to robots. Task scheduling strategy provides the resource utilization as per the user requirements. Sometimes the resources which are in demand by the user may be heterogeneous and geographically distributed. In the academia and as well as in industry, task scheduling problem is considered as a NP- Hard problems [16]. There are a lot of contributions for finding the solution.

A. SCHEDULING

In most of the computing scenario the word Scheduling is understood as arrangement of the task or rearranging the task. In cloud computing platform the task scheduling refers to the distribution of task, Scheduling and assigning the task to the virtual machines connected to the cloud. Assigning of tasks is done such that it performs at a good pace and gives the expected results in low cost and as well as in optimum execution time. The efficient scheduling provides the best results in a minimum cost with good performance. Fig.1 shows an example of two complicated tasks, TA and TB, where every task is divided into different kind of sub-tasks and the relationship among these task is represented in acyclic graph.

There are plethora of work available which are based on the different types of scheduling and is implemented on multiple applications and is successfully. Some of the examples of Scheduling are Computational Load Scheduling [17], Dynamic Scheduling [18], Insertion scheduling [19], [20], Compile time scheduling [21], Resource scheduling [22] and so on. Scheduling facilitates different services of scientific workflow, academia and all the major researches.

II. RELATED WORK

In cloud computing, task scheduling is becoming more and more popular with the demand of ease and QoS(quality of service). Numerous work been done on task scheduling in robots using cloud computing. In [32], the author has addressed multi-objective scheduling problem to minimize

TABLE 1. Table illustrating notable contribution of multi-robot task scheduling in recent time.

Author/Year	Algorithm	Methodology	Scheduling	Multi	Single	Achieved Result
Yu Zhang et al. 2013 [23]	MinProcTime, MinStepSum Heuristic	Minimum Interfere	Task Scheduling			Given heuristic is easy to implement and performance upgrading
S Giordani et al. 2013 [24]	Decentarlized Algorithm	Centralized approach	Production Scheduling	✓		A centralized model which provides more information at lower cost
N Kousi et al. 2019 [25]	Search-based Scheduling Algorithm	Mobile assistant units with online monitoring	Material Supply Scheduling		✓	Integration of multiple mobile assistant units which allows high quality solutions
V. A. Ziparo et al. 2007 [26]	RFID	Improved RFID	-	✓	✓	The number of conflicts and size of search space is reduced
S Jeon et al. 2017 [27]	Real-time Scheduling Algorithm	multi-task robot with instantaneous assignment	Task allocation algorithms	✓		MT-COM performs better with a size of fleet increases
SH Jang et al. 2012 [28]	-	GA-based task scheduling model	Task Scheduling	✓	✓	GA-based algorithm conducted diverse experiments and performance is evaluated
Z Du et al. 2017 [29]	Location based Algorithm	Robot cloud potential to serve the large amount of robots situated on different sites	Task Scheduling	✓		Virtualization of robot resource is feasible in low cost and Instead of having small centers, one big robot center is better
HR Boveiri et al. 2019 [30]	Ant Colony Optimization Algorithm	A new Robust and high-performance approach is introduced	Task Scheduling	✓	✓	Full potential of all the processors are utilized and proposed results are achieved
G Chen et al. 2020 [9]	tasks scheduling algorithm and multi-robot path planning algorithm	problem of parking robotics in high-density automated parking lot scenarios	Task Scheduling	✓	✓	Imporved the TEA* algorithm to solve the multi-parking-robot path planning problem using genetic algorithm
AR Sadik et al. 2017 [31]	Johnson algorithm	A method for planning the interaction between the cobot and two workers and scheduling among cells	Task Scheduling, Job Scheduling	✓	✓	Johnson algorithm tends to schedule the jobs based on descending the number of required units.

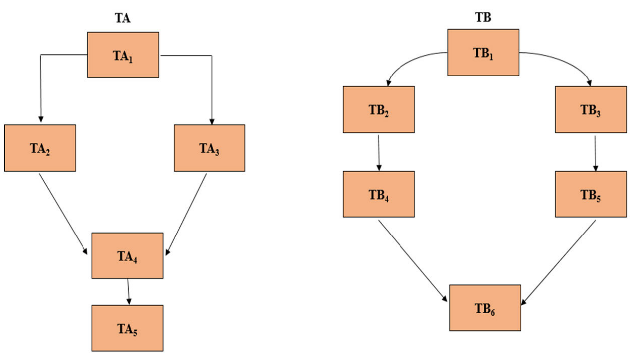

FIGURE 1. Figure demonstrating the fundamental of the task scheduling mechanism.

both the make-span and total cost collectively. Cloud Min-Min Scheduling (CMMS) and Profit Based Task Scheduling (PBTS) algorithm are being used by author and the objective is to balance the execution time and reduce the total cost in heterogeneous multi-cloud environment. Whenever any application is executing on high end server, the cost is usually more than the normal executing server. So to equipoise this cost author proposed algorithm to equalize the make-span and total cost. He et al. in Ref. [33] proposed a PSO-based Adaptive Multi-objective Task Scheduling (AMTS) strategy.To adapt the resource heterogeneity in cloud computing environments, author proposed a supporting model. Various experiments results were shown that PSO-algorithm perform well with multi-objective robot scheduling. Proposed model AMTS can minimise task completion time, energy consumption but maximize the resource utilization. The experiments showed in the paper shows that the algorithm is a effective algorithm in scheduling. The Reference [34] proposed a cloud manufacturing (CMF) scheduling model where instead of assigning the whole task to robot, a sub-task is assigned to robot. Several strategies for optimizing load balance, overall cost and processing time. In [35] and [36] Erdoğan introduced, modeled, and solved the problem of scheduling two robots. The objective is to reduce the make-span at the same time avoiding the collision between the robots while moving on single line. A few examples were taken and studied where these kinds of robots are used and how task scheduling is making them helpful. Three algorithms are well explained and performed, results obtained prove that problems can be solved efficiently for large instances with uneven workloads for the robots. Among the performed algorithms, branch-and-bound comes out to be best Computational algorithm. In [37] and [38] a survey

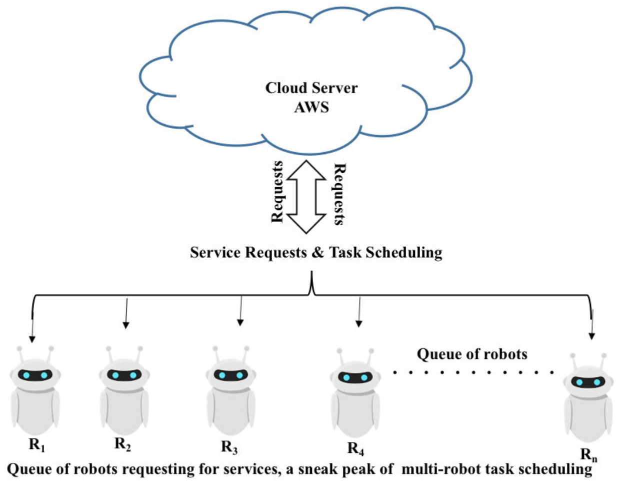

FIGURE 2. Figure showing the communication between multi-robots and cloud server.

has been done on NP-complexity models of scheduling models. Cyclic scheduling and its problem are discussed parallel analysis of their complexity is also done and state-of-art results are presented. Reference [39] presented task scheduling algorithm using Allen's interval algebra to shape feasible and achievable solutions within the scheduler. There are also work which incorporated the concepts of Big Data [40], [41]. An overview of the related works are given in Table 1.

III. PROBLEM ANALYSIS

Scheduling in multi-robots is an optimal mapping of robot-tasks into various available resources. In this section, The proposed model is presented and explained in a detailed manner. The problem is setup in the static environments with multiple robots with their urgency of completing the task is given based on the time to provide the resources. The system firstly collects all the tasks given to perform at a time. In order to establish scheduling model, collected tasks are distributed among the various robots. But the distribution is done such that each robot task takes minimum time to execute. The primary goal of the proposed work is to schedule the robot for the execution of task such that they take minimum time to execute and also provide quality of service to the users while performing the scheduling. This paper presents the working of multi-robots task scheduling with PSO and PMW scheduling algorithm to schedule them.

This paper discusses the cloud based multi-objective robot task scheduling. All the requested task are collected and mapped to the task-robots. The System performing the task can be written as in eq.1.

$$S = s|s = (D, h) \tag{1}$$

where D, denotes the different task which are requested by the users to execute in the cloud environment currently. The other variable h, denotes the happening events requested by the user to perform the task by robot.

To demonstrate this scheduling model, some assumptions are being done about the tasks, resources and scheduling of resources:

1. Tasks assigned to the multi-robots are performed and successfully completed without any obtrusion and interference by another multi-robot.
2. Tasks assigned are independent of each other irrespective of their priority of executing and are executed without taking results from any other task.
3. All tasks are evenly distributed among the multi-robots. Each multi-robot perform the task without being waiting for another robot task to revoke task robot to perform.

IV. PSO ALGORITHM

PSO (Particle Swarm Optimization) is one of the latest population based optimization technique proposed by Kennedy and Eberhart in 1995 [42]. It is bio-inspired algorithm which is based on the social behaviour of birds foraging,insect colonies or fish schooling and other animal societies. In PSO algorithm, each individual is considered as a particle, that can evolve conducting the search. Each particle represents a potential solution for a optimized problem.

The population of particle is viewed as Swarm, representing the set of points searched by the particles. Each particle in the evolutionary algorithm is well known with its personal best position (denoted as M^i) and social best position (denoted as N^i) [43], [44], [45], [46]. In each iteration, a particle (denoted as X^i) adjusts its velocity and direction to its previous best known and current positions. Particle X^i has an updating position vector (denoted as P^i) and Velocity vector (denoted as Q^i). In PSO, Kennedy and Eberhart proposed equations for updating position and velocity of particles iteratively until a stopping criterion is me [42]. The updating of position vector as shown in eq.2.

$$P^i_{j+1} = P^i_j + Q^i_{j+1} \tag{2}$$

And the formula for updating the velocity vector is shown in eq. 3.

$$Q^i_{j+1} = Q^i_j + r_1 * K_1 * (M^i - P^i_j) + r_2 * K_2 * (N^i - P^i_j) \tag{3}$$

where k_1 and K_2 are two variables called acceleration coefficients, r_1 and r_2 are two uniform random numbers in the interval [0,1].

PSO algorithm is used in various number of research and in number of different areas for influencing results.

V. PROPOSED SOLUTION

This paper proposes the concept of PMW Scheduling Algorithm for mutli-robots task Scheduling. In periodic Min-Max Weight Scheduling algorithm, the length, size and other superiority requirements are submitted to the cloud. Robots are executed on different computing nodes, and at each

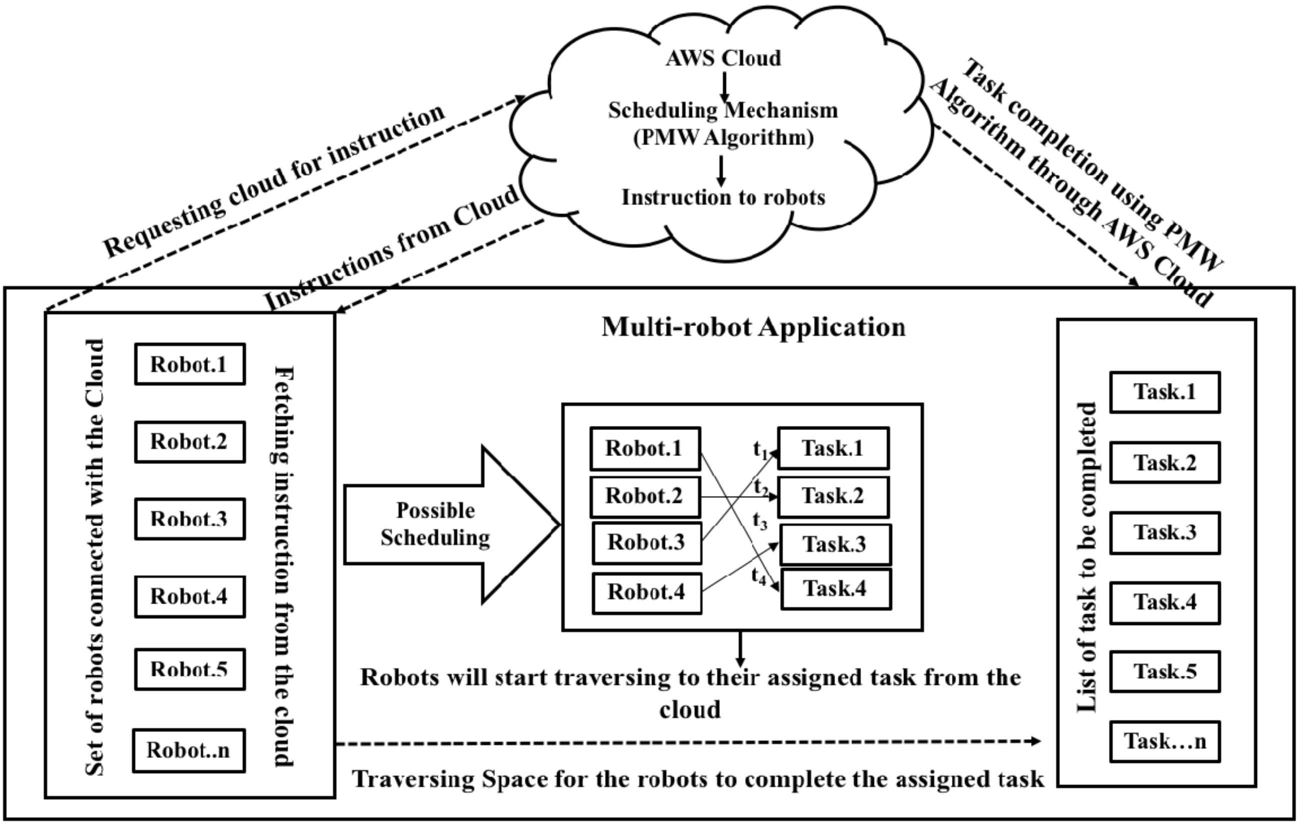

FIGURE 3. Proposed model for solving multi-robot scheduling problem using amazon web server cloud.

computing node execution time is predicted. The execution time is predicted according to the task weights difference.

Require: x Number of tasks, y no of machines, Total length L[i], priority order p[i], running speed R[j] of all the computational nodes.

Ensure: Scheduled order for execution of the tasks.

Start from $i = 0$
compute for x number of tasks
for ($i = 0; i < x; i++$)
for ($j = 0; j <= y$)
Predict the execution time for all tasks
$A(i,j) = L[i]/R[j++]$;
After predicting the execution time, Again start from first task
$i = 0$;
while $i <= x$
$i++$ *do*
Calculate average running time of all computational nodes
$q[i] = sum\ a[i,j]/y$
Difference of maximum and minimum computation time is calculated
$d[i] = A(max)(i,j) - A(min)(i,j)/q[i]$
Calculate weight order w_i
$w[i] = d_i * x / q_i$
Sort the priority of task according to the w_i
for ($i = 0; i <= x; i++$)
Assign task according to the greedy algorithm
end

The task which are divided for the computing nodes is the main criteria for the assignment of the tasks. These tasks are being sorted according to the weights of the respective task.

We have assumed the average running time of x tasks T = $t_1, t_2, t_3, \ldots t_x$ are computed on y computing nodes N = $n_1, n_2, n_3, \ldots n_y$. Weights W_i on each computational node is calculated based on the efficiency E_i and priority order P_i. After that maximum execution time $A_max(i,j)$ and minimum execution time $A_min(i,j)$ is calculated. The predicted execution time of any given task is calculated by the Total length L and running speed R of computational nodes in MIPS(million instructions per second) as shown in eq.4.

$$A(i,j) = L_1 + L_2 + L \ldots\ldots L_x / R_1 + R_2 + \ldots . R_y \quad (4)$$

Average running time for some random task q on all computing nodes q_i is calculated as submission of all execution time divided by total number of computing nodes as given in eq. 5.

$$q_i = A_1(i,j) + A_2(i,j) + A_3(i,j) + \ldots\ldots A_y(i,j)/y \quad (5)$$

The scheduling of any task for execution is decided by determining that how urgent it is to schedule. the priority order P_i and difference S_i calculate the weight order w_i for

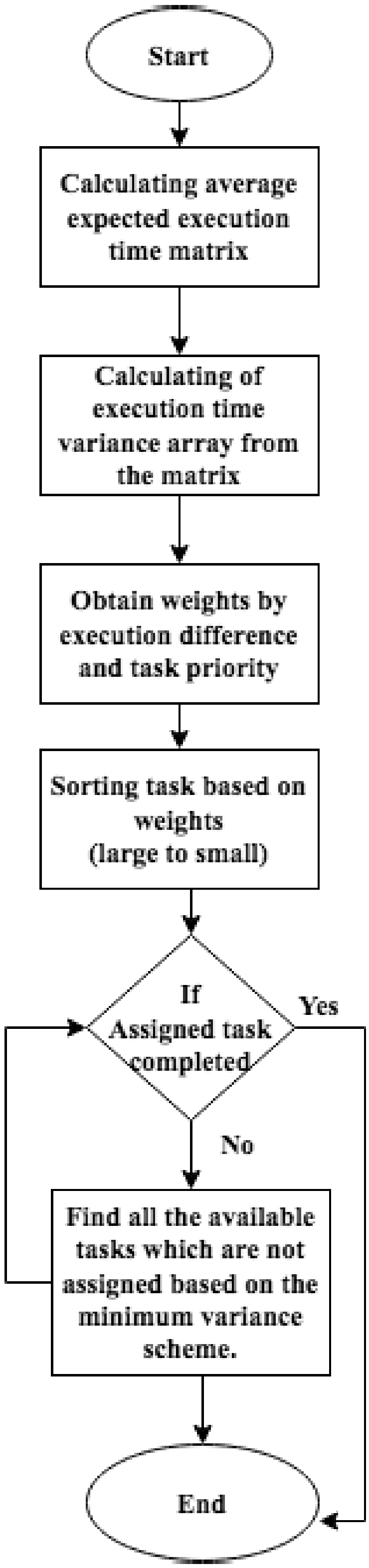

FIGURE 4. Figure representing flow graph of periodic min-max weight scheduling algorithm.

the task. The weight order w_i decides the priority order in which tasks are assigned shown in eq. 6.

$$w_i = d_i * x/q_i \tag{6}$$

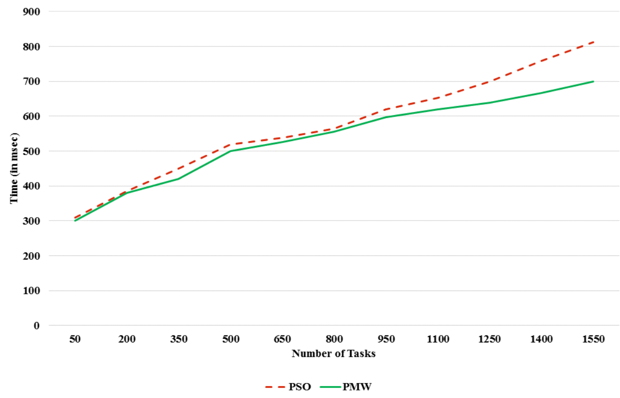

FIGURE 5. Graph representing the comparison of load balancing output of PMW and PSO scheduling on AWS cloud.

All the task now sorted according to the priority in ascending order and greedy approach is used for further results. The algorithm for assigning the tasks is described in the Algorithm 1.

A. EXPERIMENTAL SIMULATION

This sectioin presents the Amazon web server cloud for multi-robots scheduling. The details of simulation and their execution AWS Cloud is discussed in detail in this section. In this paper, Amazon web server has been used in order to evaluate the performance of PMW algorithm for the multi-robots Scheduling. The presented method is, however, applicable for any number of robots operating within a space. Here, for computation we setup the environment space in Amazon Web Server. The inputs of simulations are number of tasks, number of machines, total length, priority order and running speed of all computational nodes. A data center is created, which consists of large number of machines, one or more number of processing Units and CPUs. A data center agent is created which is incharge for coordinating the robot users and service providers. A virtual machine is created and various parameters are assigned including all the ID's and cloud task are assigned according to their parameters.

Here, set of robots which are connected with cloud Request and receive the instructions from the AWS cloud. AWS Cloud has List of tasks to be performed by Scheduling policy as described in the Fig. 5. After this, the scheduling policy is executed on the AWS cloud. All the task executed are now fetched by the robots.

VI. RESULT ANALYSIS

This section demonstrated the results of proposed algorithm on multi-robots task scheduling problem. To evaluate and compare different scheduling methods, various data are generated to simulate the proposed problem of different sizes by varying the number of task, number of robots as well as the number of sub-task per task. We took the Twelve different number of task, which are increased exponentially, as power of 2. As the number of tasks are increased, the robots

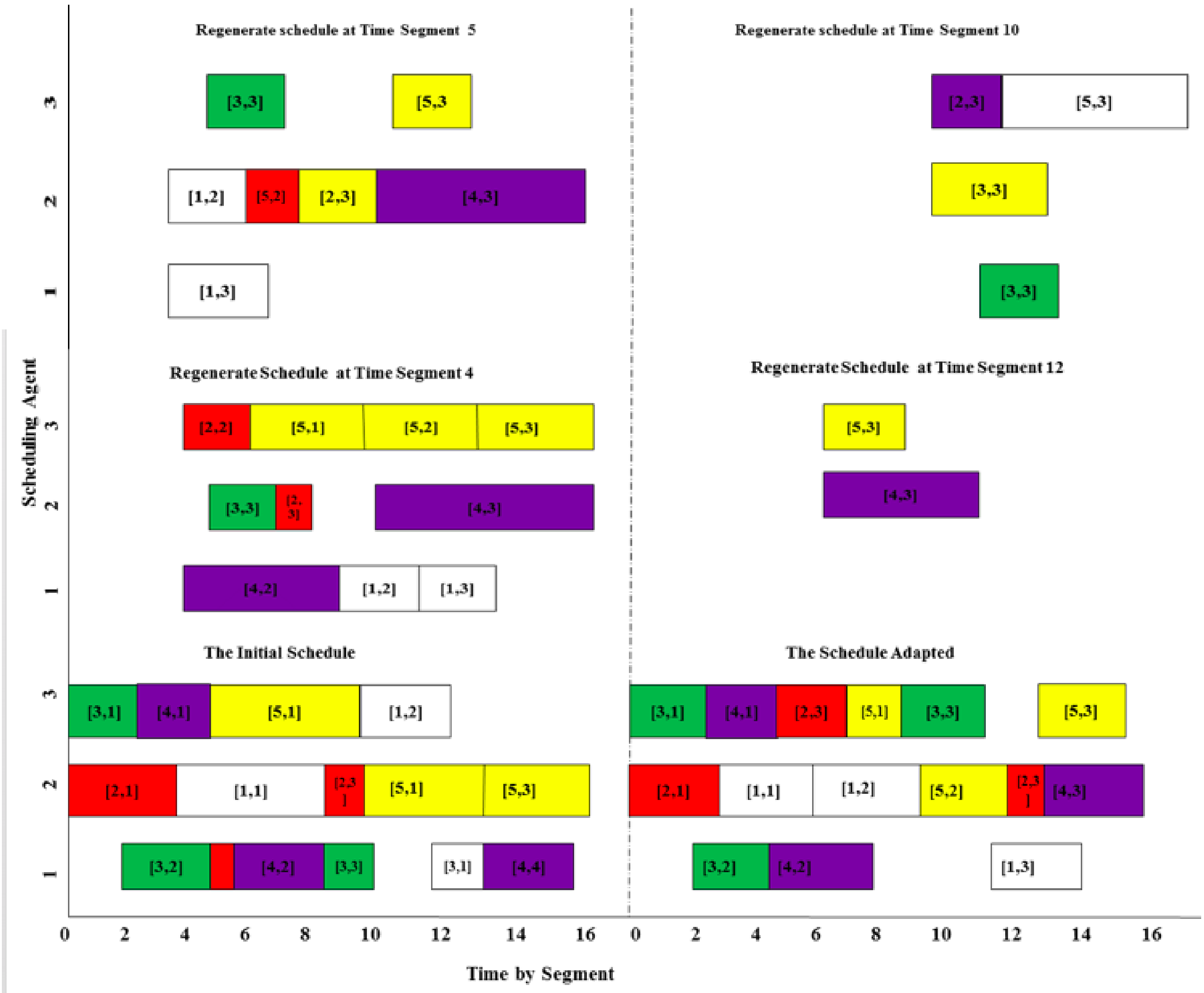

FIGURE 6. Feasible schedules adapted for processing the sub-tasks.

for simulation increases on random basis. Now the task are divided into sub-task which increases the efficiency of robots performance.

The Scheduling solution is shown in Fig. 6 in the form of Gantt chart. In the given figure, each rectangle represents a sub-task divided by the algorithm. Here [m,n] variables in the rectangle represents sub-task identity such that x_m^n. Each sub-task which the task has been assigned has its own processing time segment. The overall schedule starts from the initial schedule and regenerates at different time segments. The Scheduling algorithm repeatedly generates schedules for the sub-task, assigns them priority to the sub-tasks, which has not started processing yet at the beginning of time segment[as shown in Fig. 6]. With this information, it can be observed that starting time for any any sub-task is affected by completion of its fore-runner sub-task, the transfer time of the sub-task and the remaining time of the chosen service. Performance of different Scheduling schemes are always explored on individual sub-tasks.

The experimental results of the PMW algorithm is then compared with the results of PSO scheduling based algorithm. It is observed that the load balancing parameter is comparatively improved when a large number of tasks are performed. At the same time, It was also detected that robots are taking less time to complete the task when they are performed under the PMW algorithm. The algorithm makes the robots responsive such that it performs the tasks at given priority. Thus, providing better quality of services to the robots. on the other hand, It is also being observed that scheduling significantly reduces the idle time of the robots as compared to its initial schedule. This also provides a opportunity to restore performance and capability.

A. LOAD-BALANCING

When a large number of computing nodes are executed, to balance the load, an algorithm to schedule and allocate the robot task is needed. When same number of tasks are executed, a small variance is observed in the results of PMW

TABLE 2. Results showing the outcome of the proposed approach and their comparison with PSO and PM algorithm.

S.No	No. of Task	No. of Robots	No. of SubTask	LB using PMW (msec)	LB using PSO (msec)	LB usingPM(msec)	CT usingPMW (msec)	CT using PSO (msec)	CT using PM (msec)
1	2	1	4	17.268	17.691	17.346	0.2987	0.3135	0.3106
2	4	2	7	28.105	28.920	29.005	5.6742	6.0038	5.9901
3	8	4	13	70.703	72.012	72.902	10.7107	11.1579	11.8301
4	16	8	22	102.908	104.932	114.560	15.9713	16.9801	17.0263
5	32	20	41	150.372	153.038	161.968	28.5940	30.2330	30.9015
6	64	26	89	313.102	317.045	324.049	54.894	58.081	58.561
7	128	32	216	343.204	351.063	106.5967	112.1013	113.0864	113.982
8	256	80	376	409.006	403.157	414.749	203.0085	214.9617	215.9602
9	512	108	768	498.879	517.102	528.603	398.0104	415.9854	415.4920
10	1024	152	1489	607.298	643.938	649.750	807.2947	846.3312	849.8041
11	2048	216	2895	734.769	866.459	871.831	1627.7582	1702.7891	1717.8585
12	4096	348	5983	750.894	1085.762	1098.685	3087.3982	3264.6720	3254.7048

LB-Load-balancing, PMW- Periodic Min-Max Weight Scheduling Algorithm. PSO- Particle Swarn Optimization Scheduling Algorithm, PM- PairMatch Scheduling Algorithm, CT- Completion Time

scheduling and PSO Scheduling based algorithm as shown in Fig. 4. PMW algorithm can distribute robot task more evenly to all the computational nodes. As the number of tasks in the cloud server is increasing, the overall variance for both the algorithm is increasing but the variance of PMW Scheduling Algorithm is observed less than the PSO scheduling algorithm. Thus, Load balancing capabilities of robots are found Superior when PMW scheduling algorithm are implemented with large number of task in multi-robot environment.

B. TASK COMPLETION

Whenever deadline Scenarios are given, Completing the given tasks in desired time is really a evaluative parameter which can analyze the performance of Algorithms. The performance of the distinct scheduling algorithm is calculated and their performance is analyzed by comparing their parameters under the same conditions provided equal number of task to perform and resources available. Usually, when the number of robot task are increased, overall completion time gradually increases. By taking all the evaluative parameters and comparing it with PSO scheduling algorithm, it is observed that PMW Algorithm takes less task completion time. The completion time for the two different algorithms is also varying when they are performed under cloud server and local machine.

In both Fig. 7 and Fig. 8, The task completion time is observed when Scheduling is done using PSO-based algorithm and PMW Scheduling algorithm. After executing both the Scheduling Algorithms on the Local machine, the same algorithm is being executed on the AWS cloud server. And then, the difference in their completion time is observed and reported in the paper. It is also observed that both the algorithms are performing much better using AWS-cloud as the computing environment, when they are compared to the local machine. Completion time of the Algorithms is decreasing by 4-6% using AWS cloud server. The experiment clearly indicates that instead of performing on local machine, Computing on AWS Cloud can reduce the task Completion time. Through the observation, we can conclude that PSO-Scheduling based Algorithm and PMW Scheduling algorithm perform better and reduce the completion time by approximately 3-6%, when computed on the AWS- Cloud.

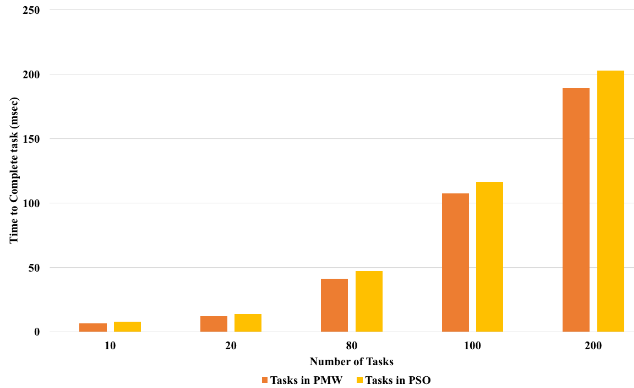

FIGURE 7. Graph representing the comparison of completion time output of PMW and PSO scheduling on local server.

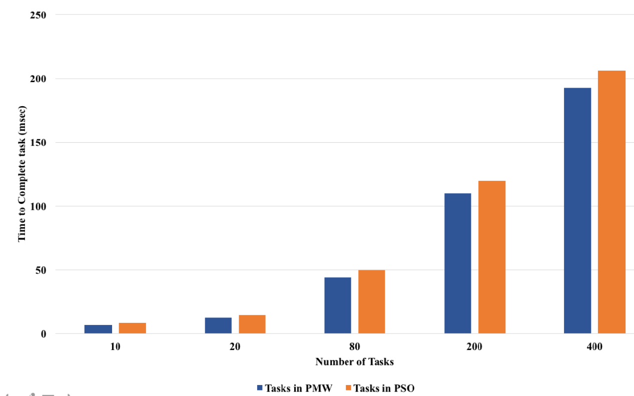

FIGURE 8. Graph based on the completion time of PMW scheduling and PSO scheduling when performed on AWS-cloud.

TABLE 3. Order of tasks for PMW and PSO scheduling algorithm.

ET Order	PO-PMW for ET	PO-PSO for ET	PO-PMfor ET
1	4	7	9
2	7	9	4
3	9	4	12
4	8	11	10
5	10	12	9
6	11	10	7
7	12	8	11

ET-Execution Time, PO-Priority Order, PMW- Periodic Min-Max Algorithm, PSO- Particle Swarm Optimization, PM- PairMatch Algorithm

C. QUALITY OF SERVICE

When the user needs quality services, requesting task is performed on urgency by executing the tasks assigned, then it provides the service quality based on performance. The more urgent task is required to execute at an urgent level for which priority of executing the tasks is assigned. It is observed that multi-robots when performed under the PMW Scheduling algorithm, the priority order is rearranged in the algorithm such that the urgent task by the robots is performed on a priority basis. Here, the lower the number of the task, higher is its priority to provide the service at urgent and is compared and presented in Table 3. So whenever the Urgent task is responded at urgent basis, quality of performance of the overall system improves. In order to evaluate the quality of service of performance, the priority order for the two algorithms is being generated and reported.

VII. CONCLUSION

Multi robot environment in itself is a complex task to solve the issues of existing environment. This paper deals with the issue of scheduling the robots based on the task available in the environment. The paper proposed the PMW algorithm for assigning the task to robots in an efficient manner and to make it more effective the AWS cloud platform is utilized. The parameters considered are the completion time and the load balancing factor for the task. The proposed approach is validated by considering different scenarios which are presented in the paper. The results of 12 different scenarios is compared with two other relevant work and presented in the paper. The outcome in each scenario is showing the performance progress of about 2-3% in load balancing and about 4-6% time efficient in completing the task. The results are encouraging and motivates to take up for some more parameters as a future course of action and extension of this work.

DECLARATION OF CONFLICTING INTERESTS

The authors declared no potential conflicts of interests with respect to the research, authorship, and/or publication of this article.

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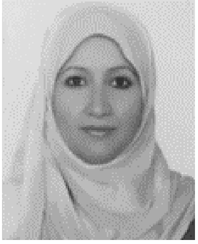

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