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International Journal of Advanced Science and Technology
Vol. 29, No. 9s, (2020), pp. 98-105

Comparison of Genetic Algorithm, Particle Swarm Optimization and improved Ant Colony Optimization for Scheduling of Heterogeneous Systems

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Abstract

Heterogeneous systems scheduling is one of the important tasks in the field of parallel computing systems. Load partitioning is one of the effective solutions for this problem. Developing a heuristic algorithm gives better results for scheduling on this system. In this paper, we propose a hyper-heuristic scheduling algorithm based on a genetic algorithm and modified ant bee colony algorithm. An optimal model is developed to determine the number of load fractions, number of rounds in multiple processor systems. First, the best candidate solutions from the population are determined. Many heuristic algorithms like genetic algorithms and PSO are applied to find the optimal activation order of the heterogeneous systems. The improved particle swarm optimization and ant colony optimization is applied to find the optimum load fraction. The Simulation results show the comparison of performance in terms of standard deviation, mean, throughput and execution time.

Keywords: *Hetereogeneous Systems,Divisible load theory, Improved Ant colony optimization, Reproduction operators, real coded GA*

1. Introduction

In parallel and distributed systems, load division is an important task to obtain effective scheduling on the available processor in the multiprocessor system[9,11]. The load is divided into small arbitrary sizes to process it in a minimum time[1,2] Scheduling is a key feature to improve the performance of load division on multiple processors.[8]Divisible the load is a special type of method in which data is divided into small arbitrary sizes and it is processed by many parallel processors[3]. Memory centric scheduling is a technique where the data is divided into time division multiple access memory scheduling[4]. Band-with centric scheduling is a process where each node makes decisions using simulations on randomly generated trees[16]

A parallel sorting algorithm for multisets is designed by multi-threading and cache technology for multi-round distribution.[17]. A Particle swarm optimization algorithm is proposed for an artificial immune system[5]. A scheduling approach is proposed based on the low-level detection operators for resource scheduling[6,10]. An energy-efficient heuristic algorithm is developed for a heterogeneous computing system[7]. Hybrid real coded GA is used to find the optimal activation order for multiple processor systems. The proposed model combined all the techniques of several heuristic algorithms. By the technique of improved Ant Colony optimization algorithm, load distribution strategies are used to dynamically predict the fitness value of the processor[12,13].

2. Previous Related work

Many heuristic algorithms are available similar to the objective of the projected research, the related approaches used in the present is as follows

2.1 Real Coded GA for Data Partitioning and Scheduling

A hybrid real-coded GA is used to determine the total candidate solutions for the load distribution. In this algorithm, load fractions are determined by using the candidate solution. The load fractions are supplied to different processors in different rounds at various instants. A good activation order can be obtained if the total processing time is minimum. Prediction of load fractions in future rounds is done..It utilizes the variation of mutation and crossover operator. The solutions obtained by these operators always balance the equality constraints at any time. This GA uses floating-point representation or continuous representation. Hybrid genetic algorithms provide effective good solutions to many optimization problems[14].

3. Proposed model

In this model, a hybrid real coded GA and improved ABC algorithm is used for the effective data partitioning and scheduling

3.1 Scheduling problem:

Scheduling is a process of allocation of loads to many parallel processors with time variants in a multiple processor system. There are m load activation orders in the project. Totally it has n processors participating in it,

Load activation order ={A1, A2, …. Am} (1)

Processors used ={P1, P2,…Pn} (2)

3.2. Scheduling Constraint

The main goal of the data partitioning problem is to determine the size of the load fractions at each installment assigned to each of the processors such that the processing time of the entire processing load is minimum. The Scheduling Constraint as follows

Scheduling of P = LF*R

Where

R=Processing rate

LF - Load Fraction

Finish time is the time required for the processor to complete the task for that processor for all the given rounds. Every round there is an initial processing time for each processor in each round. Latency is called the time taken for each processor to start processing the load. The proposed block diagram is shown in Figure 1.

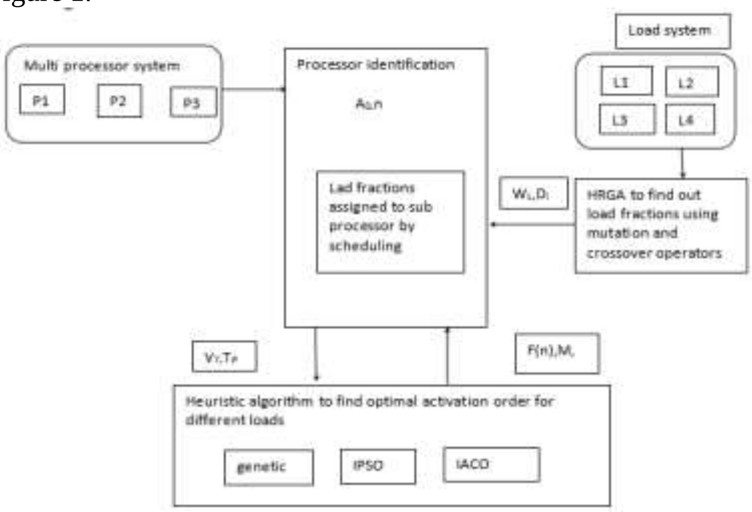

Figure.1 Proposed Block Diagram

3.3. Affine Communication model

In this model, there are may processors acting with the predetermined speed. The processor is given a fraction of load dynamically at every installment with the processing speed of the processor. Every round the latency is calculated for every available participating processor. Load distribution is given to each processor depending upon the load fractions. Multiple load fractions are utilized to find the best optimal order. This type of affine model is very effective in multiple processing system environments.

The different Strategies used in affine communication model are
Strategy 1: Assign first and second rounds of loads to processor 1 and processor 2 Strategy 2: Assign first rounds of loads to processor 1 and first and second rounds of loads processor 2
Strategy 3: Assign first and second rounds of loads to processor 1 and first round load to processor 2
Strategy 4: Assign second round load to processor 1 and first and second rounds of loads to processor 2
Strategy 5: Assign first and second rounds of loads to processor 1 and second round load to processor 2

For every strategy, the total processing time is calculated. All the strategies are applied and to find the best activation order for the minimum processing time for the optimal participating resource and the optimal number of rounds of distribution of load, For larger problems complexity is higher and we propose an algorithm that gives better results for minimum processing time.

4. Mechanism of hyper heuristic scheduling

In this proposed model, the heuristic algorithm is generated by using real coded GA and improved Artificial Bee Colony optimization algorithm. They are implemented to find the optimum number of processors required in each of the rounds.

Parameters used are

M_R	-Resource queue
W_L	- Workload
A_m	-Activation order
F(n)	- fitness function
T_p	-Task partition
V_T	- Task velocity
T_p	-Partition of task
M	-Make queue

4.1 Scheduling using Real Coded Genetic Algorithm

During the integration of two heuristic algorithms, every iteration gives a better output due to the combined advantages of both algorithms. Real coded GA creates the population size by varying mutation and crossover property.The process is dynamic in nature and load fractions are generated..These heuristics are based on some strategies. The reproduction operator is used to finding which processor is idle during every round. Load fractions are distributed to the idle processors during the next round.

The idle processor is determined by

$$p^x = 1 + \frac{x}{n(n-l)} + \frac{x^2}{n(n-2)} + \frac{x^3}{n(n-3)} + \dots,\ 0 < x < n-1 \tag{3}$$

The available processor is effectively mapped to subsequent rounds. The mutation and hybrid crossover operator will generate the necessary constraint for the population to each distribution of load.The mutation operator utilizes the load fraction diversity available from different processors. Cross over operators generates the next available processor to carry out the load fraction

4.2 Improved Particle Swam optimization scheduling

In this type of scheduling technique, every processor is supplied with a load fraction. Every task is considered as the load fraction. Load fraction is the particle for IPSO. The entire space consists of all the processors participating in the algorithm. The solution is obtained by which the processor updates the particle evolution. For every round of processing of load fractions, local best and global best processor is determined. Depending on the fitness function, the termination condition is met. Changing the value of inertia weight from positive constant to positive linear value produces a better global and local search.
Each task (particle) treated as a point in N-dimensional Space
particle position is

$$V_i^{k+1} = wV_i^k + c_1\, rand_1(\ldots) \times (pbest_i - s_i^k) + c_2\, rand_2(\ldots) \times (gbest - s_i^k) \quad (4)$$

4.3 Improved Ant colony optimization scheduling

Ant colony optimization is a metaheuristic algorithm. It is based on ants' foraging behavior. While searching for the food, ants first search the area surrounding their nest in a random manner. While movement on the path, ants leave a chemical pheromone trail. Ants have the capability to smell pheromone. Ants smell different pheromone paths but choose the strongest pheromone path. When it finds a food source, it checks the food quality and while returning it leaves some of the pheromones on its return trip, The pheromone trails can vary depending on the quality and quantity of the food[3].

4.3.1 Process: The number of tasks, load fractions, number of resources and its parameters are given.
2. Each task is given assigned a load fraction means to each processor.
3.The task is allocated to the resource and it is recorded in the make-span queue.
4. This load fraction is allocated for all the ants
Consequently, the probability of task Ti scheduled in the k^{th} iteration

$$p_{ij}^k = \begin{cases} \dfrac{[\tau_{ij}]^\alpha [\eta_{ik}]^\beta}{\sum_{l \in N_i^k} [\tau_{il}]^\alpha [\eta_{ik}]^\beta} & \text{When } j \in N_i^k \\ 0 & \text{Else} \end{cases} \quad (5)$$

Depending upon the pheromone trails, quickest processing ants for each round is available in the make span queue which gives the optimal activation order.

5. IMPLEMENTATION AND RESULTS:

In this paper, the implementation is done by IACO and it is compared with the IPSO and real coded GA algorithm. For simulation purposes, 15 processors are used. Rounds are varied depending on the load. Every load fraction is assigned a unique number. It has the value of start and end time.

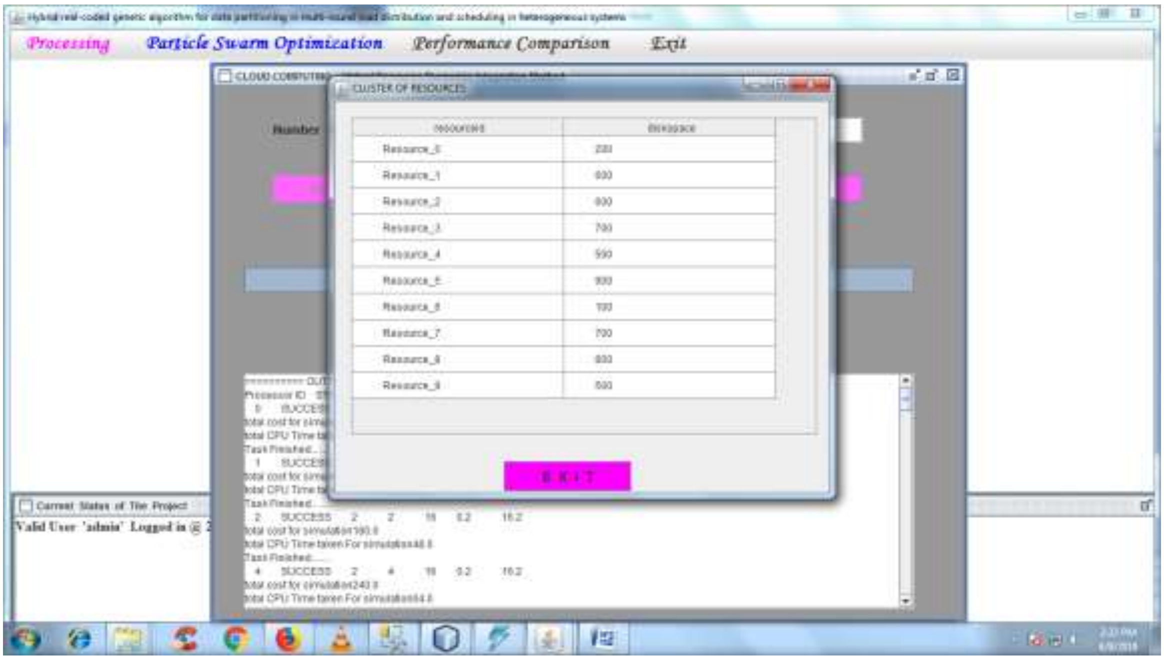

Figure.2 Cluster of Resources

The resources are grouped to a set of clusters and loads are divided into arbitrary load fractions assigned to the different processors is shown in Figure 2. The comparison chart of the execution time of the processor in GA, IPSO, IACO is shown in Figure 3.

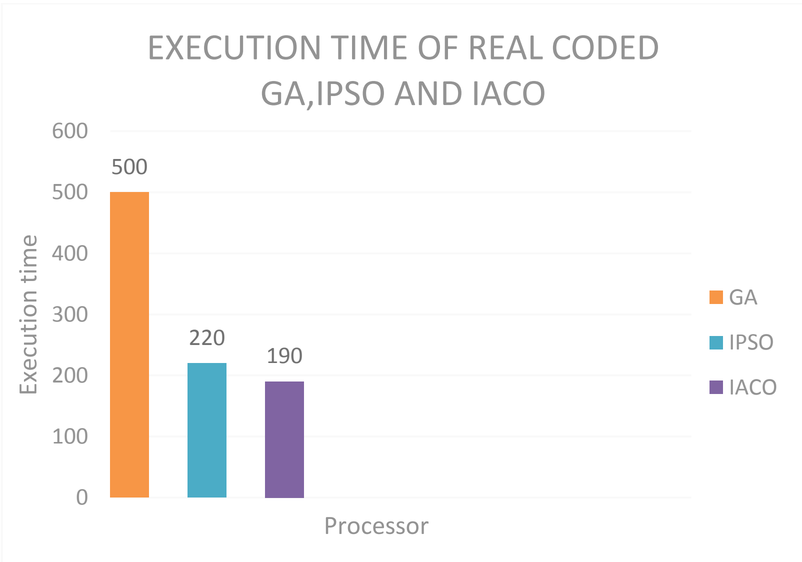

Figure. 3 Performance comparison chart of Execution timevs Processor

The execution time is very high in genetic algorithm whereas in particle swarm optimization is less and in Improved ant colony optimization algorithm is very less. Figure. 4 shows the comparison chart of throughput value and transfer unit value of processor in GA, IPSO, IACO

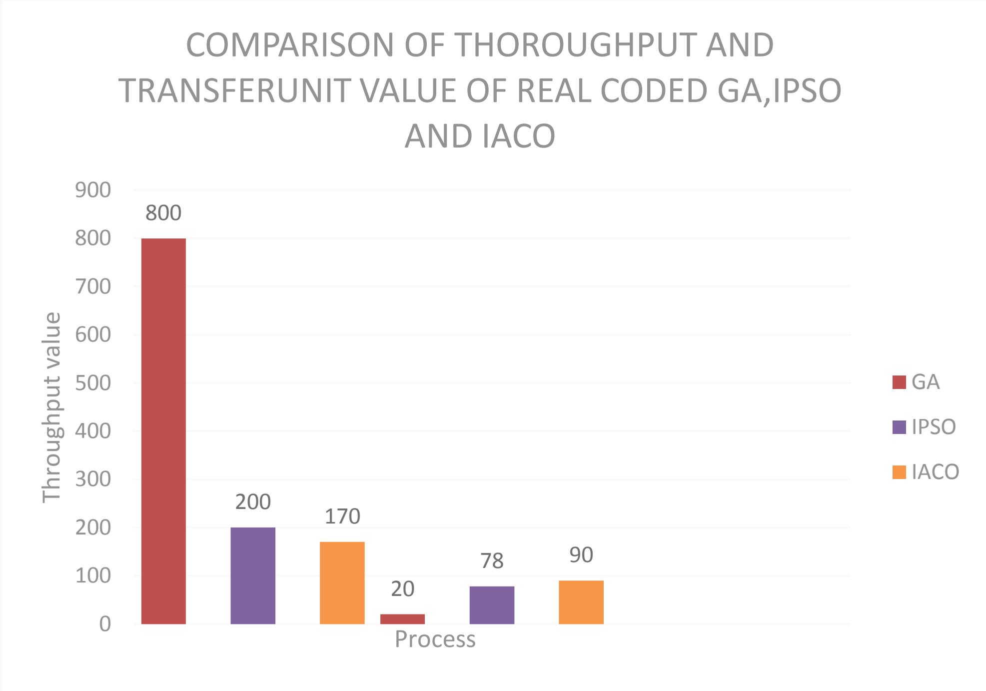

Figure.4 Comparison Chart of Through Put and transfer unit value

From the chart, we implies that throughput is reduced and transfer unit is increased in IACO when compared to GA and IPSO.

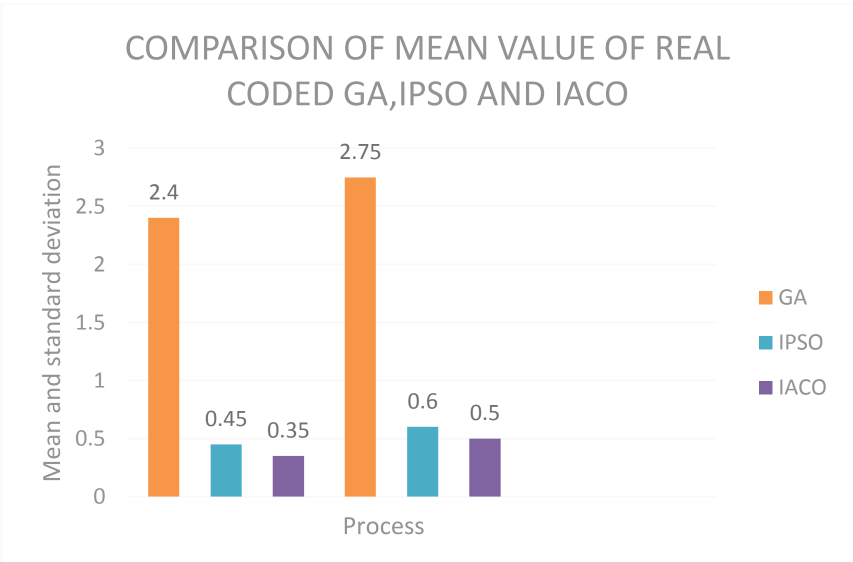

Figure.*6* Performance Comparison of Mean and Standard Deviation

Figure. 5 Shows the comparison chart of the mean and standard deviation of the processor in GA, IPSO, IACO

5. CONCLUSION

Three different heuristic algorithms are tested in the project. Multi rounds of load fractions are produced in this project. Load fractions are calculated. Scheduling is carried out real coded GA,

ISSN: 2005-4238 IJAST

IPSO and IACO. Resources are grouped to some clusters. Load fractions are given to sub processes. Simulation analysis indicates the fast execution time is given by IACO rather than GA and IPSO. The transfer value indicates how the load is transferred to the process quickly. IACO is quicker than the other two algorithms. Hence IACO is proved as the quick algorithm when compared to real coded GA and IPSO.

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