A Comparative Study of Heuristic Algorithms to Solve Subtask Scheduling Problems Under Cloud Computing Environment

Suma T[1]and Praveena Kumara K.M[2]
[1]Department of Applied Sciences, New Horizon College of Engineering, Karnataka-560103, India.
[2]School of Applied Sciences, REVA University,Bengaluru, Karnataka, India.
Email: sumatmaths@gmail.com

Abstract:
This work consists ofcomparative analysis of the meta-heuristic algorithms to solve subtask scheduling problems under cloud computing. Cloud computing is well suitable for addressing computational requirements of greater task sizes and this type of problems are considered as NP-complete hence, requires an optimal scheduling algorithm. Numerous schedulingapproaches have been made to address such type of problems but selecting an optimal algorithm for the problem under a specific nature is a difficult task as the algorithms are developed under diverse assumptions. Therefore, this work discusses two heuristic algorithms namely Artificial Immune (AI) algorithm and Particle Swam Optimization Algorithm (PSO) for order scheduling problem. The objective considered here is minimizing the make span.

Keywords: Heuristic algorithms; Subtask scheduling; Cloud computing; Artificial Immune System (AIS); Particle Swam Optimization (PSO).
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1. Introduction

In manufacturing industry, the task generally refers to a process involved with the aim to convert resources (materials) into finished goods. Planning decides the activities of manufacturing industry. Hence any changes in the planning and scheduling affects the complete recital (performance) of the industry. So, it's important to develop an effective scheduling approach to expand the productivity of the manufacturing industries. In manufacturing environment, the productivity can be termed as the number of jobs produced per unit time, finished goods reaching the customer on time, resource utilization and many more. The common objectives that manufacturing industry seek to optimize includes makespan (time required to complete the product out of the system), tardiness, lateness, manufacturing cost, transportation cost and setup time etc.

Cloud manufacturing is a service-oriented industrial model. CM incorporates altered tools like networked industrialized, to sustenance reminder, division and administration of industrial possessions. Cloud computing is being gradually accepted to transmute the way that possessions are applied and inspired. Accordingly, the industrialized business is discovering cloud computing in order to progress current business arrangements and innovativeness arrangements, to deliver networked business amenities, and to improve placate detailed business innovativeness needs[16,17]. Researchers have suggested a many novel

procedures and tactics to summarize several virtualized business properties and proficiencies.

The increasing complexity in manufacturing industry and growing interest in bio immune and Meta heuristic-based technologies for solving multi-objective subtask scheduling problems has driven the interest for taking this research. The heuristic algorithms are reliant on the problem and searches the solutions based on problem features. Their solution is built on learning and investigation in which a comprehensive and scientific search to find an optimal response is applied. However, these algorithms are greedy and usually trapped in local optimal. This paper explains the basic concepts, working mechanism, and the applications of heuristic-based algorithms such as AIS and PSO algorithm.

2. Literature Review

Many meta-heuristic algorithms are developed and conducted comparison study by researchers to obtain optimal results for the scheduling algorithms which includes Artificial Immune system[9], Genetic Algorithm, Particle Swarm Optimization [21,15], Tabu Search and so on. [11, 12] studied PSO and proposed the optimal selection and resource service composition to minimize the cost and time by maximizing the reliability. Computational results shown that the method can be used to obtain the optimal solution. [13] considered the objective of minimizing the maximum earliness and makespan. They implemented 'branch and bound' method to obtain Pareto optimal solutions and an algorithm based on heuristic to obtain the best possible solutions. Numerical results show that the branch and bound approach can solve problems up to twenty-five jobs. [18] developed a hybrid algorithm of PSO and SA to multi-objective FJSSP. PSO is developed to allocate operations on each machine and SA to assemble operations on each machine. [7] proposed a Pareto GA with a collection of non-dominated solutions to a local search. The objectives considered are minimizing the makespan and total flow time. [8] suggested a PSO which adopts new ideas and moves to identify the superior particle's location in the swarm [9] Implemented AIS based Algorithm to minimize the cost and load balance for industrial robots in CM. The Computational result validated the optimal performances on the mentioned optimizing objectives.[3], conducted comparative study on heuristic algorithms for solution quality and runtime, their results show that comparisons between evolutionary algorithms, produces accurate and unbiased results. Study between SA and GA for solving the Travelling Salesman Problem was conducted by [1], the outcome of the research revealed that SA runs faster than GA and runtime of GA increase exponentially with number of towns. However, when it comes to quality of the solution GA performs better than SA. [2] compared GA and TS approaches to solve scheduling problems. The results clearly shown that TS produces better solution then GA with respect to computing time. However, GA can produce many diverse adjacent optimal solutions at a time because of the generation of chromosomes from different parents. [19,20] consists of heuristic methods such as SA, TS, and PSO; the main objective of the study is to compare the qualified percentage deviation from the best-known solution which is introduced in QAPLIB. The outcome of the concluded that TS is the best method in respect to computational time. [4] were known to conduct research on customer order scheduling problem for the first time in 1990. Later, many researchers were focused on order scheduling on single machine. The multipart analysis of the problem with the objective of minimizing total completion time is studied by [10,6] shown that the machines $m \geq 2 \& m \geq 3$ is NP-Hard for the order scheduling problem of minimizing total weighted completion time. From the literature review it is evident that no comparative study conducted between AIS and PSO for subtask order scheduling problems in cloud computing. Hence, this research made an attempt to study a

comparative study between AIS and PSOto solve subtask scheduling problems under cloud computing environment. [23]Conducted the comparative analysis of AIS and PSO for task scheduling on smart devices. The proposed method optimizes for Decrease in makespan, uniform distribution of tasks and decreased response time.

3. A Comparative Study of AIS v/s PSO

3.1. Artificial Immune System (AIS)

AIS is an artificial intelligent technique used in scheduling problems from now more than ten years. AIS are inspired by immunology theory of vertebrates and working mechanisms of immune. It acts as a powerful tool to currently existing techniques used for pattern recognition, design, modelling and control. The learning process in AIS is the interaction between antibodies and antigens populations which provides a unique self-approach for the inward organizing network structures. Each AIS corresponds to unique number of possible potentials in the presented solutions. The capability to generate novel solutions in a period of short time, inbuilt memory management, robust recognition and self-tolerance are other important features of AIS. These tremendous features made researchers to use AIS to solve scheduling problem. The main goal associated with all scheduling problem is finding a best scheduling which minimizes the makespan. Each solution is an Antibody (Ab); number of libraries will be built each containing a number of genetic threads, these threads are considered as a scheduling solution to the problem. By concatenating threads from each library an antibody (schedule) is formed. Thousand clones of the best were formed. The clones were modified and therefore the best clone formed is taken into account.

In the development of Clonal selection-based algorithm the following aspects were considered; collection and cloning of efficient stimulated cells, affinity mutation and recollection of the clones with high affinity, hyper mutation of cells proportional to their affinity, preservation of the memory cells, decease of non-stimulated cells, production and preservation of diversity. In the algorithm, antibody is an entrant agenda and antigen are a participant agenda which will be the best agenda till that time prompt created by the algorithm. The stepwise working procedure of the algorithm is given below.

- Generate initial population of antibodies that is generation of potential schedules.
- Obtain the affinity of the generated antibodies.
- Generate clones for each antibody; calculation of number clones to be generated depends on the affinity of the respective antibody.
- Generate maturated cloned population by hyper mutation process.
- Choose the best clone and discard the remaining clones.
- Considered the new population as a candidate for the next generation.

This mechanism is continued till the best solution is obtained. This is the best schedule for the optimal problem considered, meeting the pre-defined constraints.

3.2. Particle Swarm Optimization (PSO)

PSO is an evolutionary populace based intelligent method inspired by the social activities of animals like school of fish etc [3]. The remarkable features of PSO made the researchers to focus more on this technique.PSO optimizes through social evolution, very simple to use, requires simple mathematical tools, and low-cost. Here are few applications that have implemented PSO technique are; chemical engineering, data mining, the voltage control problem, environmental engineering, pattern recognition, to solve Scheduling problems and task allocation.The PSO is analogous to the existing evolutionary Algorithms. The number of particles represents a problem space. All particles possess fitness values which are calculated using fitness function, fitness values are optimized in every steps. Each particle has its best position denoted as *pbest,* is the best fitness value (result) reached by the particle. The best position among the total group of particles denoted by *gbest*, is the

best particle fitness in a total population. The size of the population is problem dependent the most general sizes considered are 20–50 [15]. In each generation the velocity and particles position will be calculated using Equation 1 and 2, respectively. The first term of the formula(1) is the inertia of the past velocity. The second term indicates individual thinking, and lastterm is social consciousness, indicates coordination between the particles. The particle fresh position is obtained by summing up new velocity to the existing position as per formula(2).

$$V_{i,k+1} = wV_{i,k} + (rand)_1\, C_1\left(P_i - X_{i,k}\right) + (rand)_2 C_2\left(P_g - X_{i,k}\right) \quad (1) \qquad X_{i,k+1} = X_{i,k} + V_{i,k+1} \quad (2)$$

Where,

$$\left[\begin{array}{c} "i = i^{th} particle \\ X_{i,k} = position\ of\ partcle\ 'i\ 'in\ iteration\ 't' \\ V_{i,k} = velocity\ of\ particle\ 'i' in\ iteration 't' \\ p_i = previous\ best\ position\ of\ particle\ 'i' \\ P_g = previous\ best\ position\ among\ all\ the\ particles(g_{best}) \\ w = inertial\ weight - balances\ local\ and\ global\ exploitations\ of\ the\ particles \\ C_1 and C_2 = learning\ factors - controls\ the\ influence\ of\ p_{best} and g_{best} on\ search\ process \\ (rand)^1 and (rand)^2 = random\ numbers - taken\ within\ the\ range\ [0,1]" \end{array}\right.$$

3.2.1 The summarized process for standard PSO is given below

- Initialization of particles population with their arbitrarydisplacements and velocities.
- Estimation of the suitability ideals of all elements, set *gbest* of each unit like to its existing place, and set *gbest* identical to the place of the best original element.
- Calculationof particles position and velocities using Equations (1) and (2).
- calculation of fitness values of each particle and comparison of existing fitness value with its p_{best} value. If the existing value is better, then update $p_{best}$with the existing position and fitness value.
- Finding out the best fitness value. If the fitness value is better than g_{best}, then update g_{best} with the existing best particle.
- After maximum iterations reached(converges), the output is g_{best} if not, repeat from Step3.

This section provided general information and discussed the basic concept and working mechanism of heuristic-based algorithms such as AIS and PSO. AIS has attracted many researchers because it has capability to generate new solutions in short period of time, Robust recognition and self-tolerance similarly PSO algorithm has got advantages because of its simplicity of usage and it only requires simple mathematical operators.

4. Customer order scheduling

At existing, many business enterprises are agreeing the multi-objective business approach. The proposed approach, customer order contains the diverse artifact types, also the complete scheduling order should be conveyed concurrently. Thus, obligating a supply target date for a given order and the cumulative application rate of business resources are the main issues. The manufacturing system explored in this work includes several kinds of machines; each one is dedicated to only one kind of product. Each order consists of a greater number of products; each one can be managed using a dedicated machine. The achievement of all order is distinct by the time at which all the tasks are finished. Due to customization, the manufacturing industries are transforming themselves into service providers and they are adopting modern technologies. This research

considered a heuristic-based algorithm to schedule a customer order scheduling in CM.

4.1. Cloud manufacturing system

A stepwise cloud manufacturing processing procedure is as follows:

- Middle wares will be going to introduce CM to the system.
- Users places a task application using internet.

4.2. Optimization strategy

- Scheduler decompose the task into number of subtasks and after analysing the current working state of a machine allocates each subtask to a machine.
- machine's starts handling the assigned subtask to them.

Table.1Parameter setting for stimulation

Parameters	Values
No. of orders N_o	5
No. of Machines N_m	30
i[th]machine performingj[th] task $M_{i,j}$	10
No. of subtask N_{st}	15
No. of ProcessorsN_p	15
No. of Task N_T	8
Number of subtasks in a process	[5, 9]
Number of functions for each machine type	[1,5]

5. Result and Discussion

Simulation parameters are set and optimal solutions are obtained using MATLAB. Parameters are fixedand shown in table 1. It is considered that 5 sub-task types occur in each layer with probability of 70%. 15 diverse task type distribution scenarios are designed randomly and assigned to 30 different machines types. 10-task types are obtained by assigningvarious workloads taking$N_T = 15, 20, 25 \ldots\ldots 60$. To attain the optimal schedule, experiments are conducted on these diverse types. Algorithms converges when there is no difference $< 0.5\%$of fitness values of a new generation. The convergence for number of generations for algorithm vary from [50 110]. At last, performance indexes of overall completion time are obtained and these results are plotted as shown in Figure 1. Results shown that the considered method can obtain the optimal schedule for the considered problem. It is also noted that the performance of PSO algorithm is better than AIS as completion time of the task is less using PSO then the AIS.

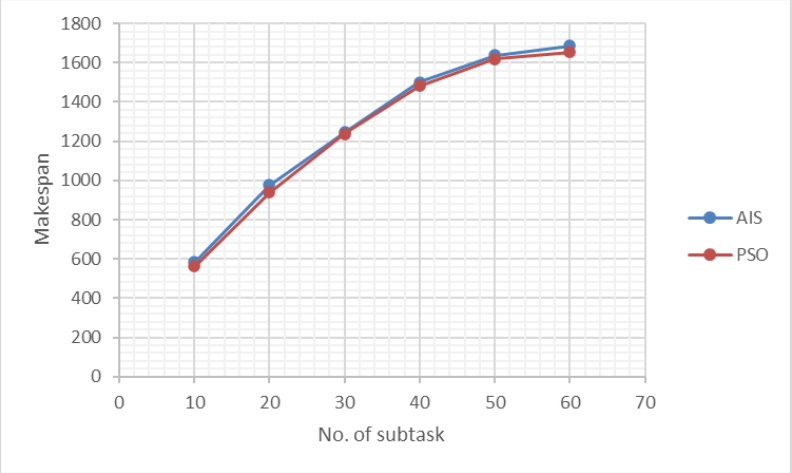

Fig. 1.Number of Subtask and Makespan -AIS v/s PSO

6. Conclusion

This research focused on comparative study of two heuristic algorithms namely PSO and AIS for solving customer order subtask scheduling problems in cloud computing to minimize makespan. A PSO and AIS algorithms are studied and implemented to obtain the optimal schedule. The proposed PSO and AIS algorithms are compared to know the better performance with respect to makespan. The simulation results indicated that, PSO and AIS algorithms acts as an effective tool in obtaining the optimal solution ofminimizing the makespan. PSO algorithm shows better results compare to AIS.

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