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Cloud Manufacturing Environment and Optimal Resource Allocation Based on Swarm Intelligence Hybridized Algorithms

Raqeyah Jawad Najy [1*], Adel Thaker [2]
[1] Department of Industrial Management, Al-Furat Al-Awsat Technical University, Kufa, Iraq
[2] University of Mosul, Mosul, Iraq

* Corresponding Author: **Raqeyah Jawad Najy**

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Abstract
Swarm intelligence algorithms have proven their importance and efficiency in solving complex optimization problems, especially the problem of optimal allocation of cloud manufacturing resources. Therefore, in this study, a hybrid algorithm consisting of the particle swarm (PSO) algorithm and the ant colony (ACO) algorithm was proposed to reach the optimal allocation of cloud manufacturing (CMfg) resources for the electrical distribution transformer product. The objective function here is four-dimensional, that is, the optimal allocation of resources is aimed at reducing the time, cost, risk, and quality of the service provided. The results obtained showed the effectiveness and efficiency of allocation of cloud manufacturing (CMfg) resources using the hybrid algorithm (AC-PSO).

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Keywords: Hybrid Swarm Algorithm, Cloud Manufacturing, Allocation Model, Allocation Method

Introduction

Through modern manufacturing problems and significant and accelerated technical change, manufacturing industry is facing the problem of low use rate. the ‘high-quality’ resources are indolent, and most importantly, there are other places or sites that suffer from a lack of resources. Therefore, manufacturing resources must be distributed fairly to meet all customer requirements. So, the problem of allocating CMfg resources will have significant limitations, and the allocation model and algorithm used for this purpose will greatly affect the process of forming manufacturing resources. Swarm intelligence (SI) metaheuristics, namely, ant colony optimization (ACO) and particle swarm optimization (PSO Which have proven to be excellent and efficient optimization algorithms for solving difficult resource allocation problems [1]. The ant colony algorithm has proven its effectiveness, which simulates the natural behavior of ants in search of food and access to the food source in the shortest way [2]. In this study, a proposed model of a hybrid algorithm (AC-PSO) was presented that optimizes the solutions obtained from the particle swarm algorithm and placed them in the initial ant pheromone matrix in order to reach the optimal solution through a multi-objective optimization process to reduce time, cost, risk, quality of service provided to the customer in the cloud manufacturing (CMfg) environment.

Problem Determination

The problem of allocating cloud manufacturing resources begins with the first step on the cloud manufacturing platform when the customer starts posting his request for manufacturing services (product/ service), then the request is transferred to specialized factories to carry out the task, and before that, manufacturing resources must be allocated optimally to ensure the operation and continuation of the product manufacturing process easily and efficiently.[3, 4, 5, 6, 7, 8]. In this stage, we conduct a study on a distribution transformer manufacturing process, which needs collaboration from others because of business requirements or the limitation of its processing. Suppose there are eight parts for process, and each one resources. Resources must be allocated to optimally process the distribution transformer that ensures the delivery of the order on time by reducing time, cost, risk and improving the quality of molecular service for each processing process and the totality of the product as a whole. The process task is split into several subtasks [Ob1, Ob2, Ob3, Ob4, Ob5, Ob6, Ob7, Ob8].

Then, prepare resources based on the task requirement and the characteristics of the resources.

Proposition Model

For the purpose of studying the problem of resource allocation of an electricity distribution transformer product [9], appropriate resources should be allocated to each part of the entire manufacturing process in a way that improves multiple performance goals according to the following assumptions.:

A. The demand for each of the four products in each period is variable and dynamic (on-demand manufacturing strategy) and this strategy represents the essence of cloud manufacturing as on-demand manufacturing.

1. A number of time periods for manufacturing systems were taken into account, as one time period could be 3 months or 6.
2. The parts of each of the four products are processed on different types of machines in a certain sequence, each product has a path with a different sequence of machines.
3. The processing times for all manufacturing processes of any product are known and constant, although they are performed on different types of machines.
4. The cost of handling and movement between different manufacturing processes for the manufacture of any product depend on the distance traveled.
5. The type of customization for each manufacturing process of any product of the linear type is usually expressed by the problems of customization as one of the types of linear programming, so all types of machines must be allocated to sites with the same dimensions for the purpose of calculating the distance between the figs allocated to two different sites by subtracting the location numbers of those machines from each other.
6. Each machine has a finite energy expressed in hours during each time interval and is constant over the allocation horizon.
7. Surplus parts or whole products can be produced depending on the volume of demand and the total cost to meet this demand between consecutive periods and used to meet new demand in the future.

Objective Function

After the four objectives are non dimensionalized, The objective function, its objectives and the constraints associated with these multiple objectives can be described as follows:: based on [10, 11, 12, 13, 14].

$$F=\min w1C+w2T+w3QoS+w4RK \quad (1)$$

1. Time T

It represents the total time to complete each task and the component of preparation time plus processing time plus movement or transfer time as follows.:

Min

$$F= i=1nTi \quad (2)$$

Constraint of the total Time of each route is:

$$j=1iTij\ xij =Ti \quad (2\text{-}1)$$

2. Cost C

The cost of the machine's working hour and the cost of the workers ' working hour, in addition to the cost of the raw materials involved in the manufacturing process for each task and the cost of processing, as follows:

min

$$F= i=1nCi \quad (3)$$

Constraint of the total cost of each route is:

$$j=1iCij\ xij =Ci \quad (3\text{-}1)$$

3. Quality of Service Q

Here is the quality of the service provided to the customer/user, which is reflected by the level of conformity between the required task and the resource allocated to it and can also be measured by the degree of customer satisfaction with the product or service provided to him.

.min

$$F= i=1nQoSi \quad (4)$$

Constraint of the total QoS of each route is:

$$j=1iQoSij\ xij =QoSi \quad (4\text{-}1)$$

4. Risky RK

A Risky reflects the number of machines actually investigating the incident. The objective function is.

min

$$F=i=1nRKi \quad (5)$$

Constraint of the total QoS of each route is:

$$j=1iRKij\ xij =RKi \quad (5\text{-}1)$$

The probability condition for a decision variable is: $xij\in(0,1)$.

That is, it takes a value equal to (1) in the case of verification and a value equal to (0) in the case of non-verification.

Where: F is the target function, n the number of instances, ij the time between nodes (resources).

Xij the value of the decision variable (0,1) is either equal to zero or one.

Determination of the AC-PSO algorithm

the flow chart of the ant colony – particle swarm hybrid (AC-PSO) algorithm is shown in Figure 1. The Right direction is the (ACO operator) process, and the left direction is the (PSO operator) process.

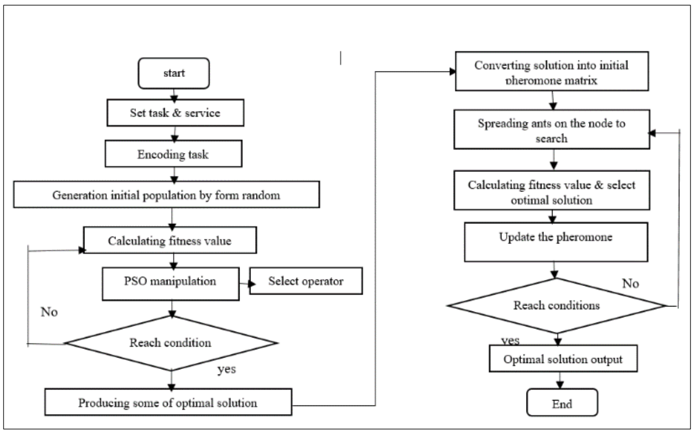

Fig 1: Flow chart of Particle swarm-Ant colony Hybrid Algorithm

Results and Discussion

As we noted earlier in the flowchart and in accordance with the proposed hybrid algorithm for the development of optimal solutions in this work, It was used MATLAB2021 programming to calculate Experimental parameter setting: the population sample size is 60, the number of iterations is 100, $\alpha = 1$, $\beta = 6$, $\rho = 0.1$, Process divided to (8) task as follow, and The weight values of the four objective time T, cost C, quality of service Qos, risky RK are [w1, w2, w3, w4] = [0.3, 0.3, 0.2, 0.2]

Table 1: constraint data of production task

it	Process	Time/m	Cost/ID	QoS%	RK%
1	Ob1	250	20	90	85
2	Ob2	200	17	85	85
3	Ob3	230	35	90	90
4	Ob4	290	30	95	80
5	Ob5	250	13	85	85
6	Ob6	280	30	95	90
7	Ob7	270	25	90	85
8	Ob8	120	20	80	75

Table 2: objective function values of task

it	Process	Time/m	Cost/ID	QoS%	RK%
1	Ob1	45	247	95	90
2	Ob2	40	225	93	92
3	Ob3	18	81	95	90
4	Ob4	29	137	88	90
5	Ob5	29	122	96	90
6	Ob6	30	148	90	85
7	Ob7	25	145	95	77
8	Ob8	20	140	95	70

Due to the simulation operation, the resource allocation program relevant to the process of each task is as shown in Table4,5, Figure 2

.

Table 3: The I Optimal Resource Allocation

Optimal Allocation	Average no.of.it
Ob1-Ob2- Ob3-Ob4-Ob5-Ob7-Ob6- Ob8	100

Table 4: Fitness values & iteration of the three algorithms

Algorithms	Fitness values	NO. of. Iteration at optimal solution
AC-PSO	117	28
ACO	119	42
PSO	121	35

Fig 2: The search by three algorithms

It is shown in this study in which the two algorithms (ACO)&(PSO) were selected for comparison with the hybrid algorithm (AC-PSO) of both. The search process in Figure (2) shows the results of comparing the three algorithms, and as in Table (4), the performance of optimization algorithms is mainly reflected by factors such as algorithm approximation, speed and optimization accuracy, the accuracy and efficiency of optimization of the algorithm is reflected by the fitness value(trade-off), and the effectiveness of algorithm convergence is reflected by the number of iterations at which we reach the optimal allocation of resources. Therefore, this study compares the fitness value (trade-off) with the number of iterations at which we reached the optimal allocation of the algorithm.The bird swarm algorithm(PSO) was the lowest efficiency and the ant colony algorithm (ACO is better than it, and from Figure(2) and Table (4), it can be seen that due to the fact that the bird swarm algorithm(PSO) has a higher fitness value than the other two algorithms, this solution to the PSO algorithm is not good compared to the other two algorithms, which indicates that the optimization effect is also not good compared to the Ant algorithm and the hybrid algorithm, since the ant colony algorithm had a lower fitness value, and the hybrid algorithm designed in this study contains the lowest value Fitness at a number of iterations equal to(28), which had the optimal solution, which is better than the ant colony algorithm to some extent, and the iterative approximation (28) is also better than the other two algorithms, and the designed (AC-PSO) hybrid algorithm proved its effective and powerful ability to find an optimal solution in the cloud manufacturing(CMfg) environment, which is characterized by its dynamic changes. The company can apply it in solving the problems of resource allocation for the distribution transformer product and all its other products by using the appropriate resources for each manufacturing task, improving the quality of service provided to the customer, as we note in Table (4), in addition to saving time and cost and reducing the severity of risk for the company under study.

Conclusion

In this work, the problem of optimal allocation of resources in the cloud manufacturing(CMfg) environment was studied, the mechanism of optimal allocation of resources was presented and described, and the problem of allocation of cloud manufacturing resources is assumed with a model of allocation in this manufacturing environment relative to the objective function set for a multi-objective optimization problem represented by reducing the time, cost, quality and risk of the product of the distribution transformer manufacturing process. Comparing both the (PSO) algorithm and the (ACO) algorithm, it was proved that the model and the proposed hybrid algorithm (AC-PSO) in this study gave stronger results than if each algorithm was used alone. By implementing a simple pheromone-guided local search to improve the performance of the) PSO (algorithm, the results show that the Ant algorithm (ACO) helps the particle algorithm (PSO) not only efficiently achieve possible solutions, but also to reach the optimal solution efficiently and effectively. The final results also showed that there is scope for research in hybridizing swarm intelligence methods to solve difficult multi-objective optimization problems, including the problem of optimal allocation of dynamic cloud manufacturing resources.

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