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An Ant Colony Optimization For Job Scheduling To Minimize Makespan Time

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Abstract *:* This paper deals with the makespan minimization for Job Scheduling . Research on optimization techniques of the Job Scheduling Problem (JSP) is one of the most significant and promising areas of an optimization. Instead of the traditional optimization method, this paper presents an investigation into the use of an Ant Colony optimization (ACO) to optimize the JSP. The numerical experiments of ACO were implemented in a small JSP. In the natural environment, the ants have a tremendous ability to team up to find an optimal path to food resources. An ant algorithm stimulates the behavior of ants. The main objective of this paper is to minimize the makespan time of a given set of jobs and achieved optimal results are encroached.

Key words*: Job Scheduling Problem (JSP), Ant Colony Optimization (ACO), Makespantime.*

I. INTRODUCTION

This paper examines an application of the recently proposed adaptive metaheuristic Ant Colony Optimization (ACO) for the Job Scheduling problem (JSP). In the static JSP, a finite number of jobs are to be processed by a finite number of machines. Each job consists of a predetermined sequence of task operations, each of which needs to be processed without interruption for a given period of time on a given machine. Tasks of the same job cannot be processed concurrently and each job must visit each machine exactly once. A feasible schedule is an assignment of operations to time slots on a machine without violation of the job constraints.(1). A makespan is defined as the maximum completion time of the jobs. The objective of the JSP is to find a schedule that minimizes the makespan.

Ant colony optimization (ACO) is a popular optimization technique, it is a population-based metaheuristic that can be used to find approximate solutions to difficult optimization problems.

In the ACO, each ant constructively builds a solution by several stepwise probabilistic decisions until a solution is reached. The ACO metaheuristic has been applied to various hard combinatorial optimization problems. For example, in the scheduling field, ACO has effectively been applied to the Flow-shop scheduling problem, Resource Constraint project Scheduling problem, etc.,

This paper is organized as follows: Section 2. gives the description of the non-preemption Job Scheduling. Brief introduction of Ant Colony optimization in section 3, Section 4. Implementation of the experimental study and last section 5 Concludes this paper.

II. JOB SCHEDULING

The optimal solution to the Job Scheduling problem involving n jobs and m machines determines the sequence of jobs on each machine in order to complete all the jobs on all the machines in the minimum total time (i.e. with minimum makespan) where each job is processed on machines 1, 2, 3, …, m, in that order.

All jobs have the same processing operation order when passing through the machines. There are no precedence constraints among operations of different jobs. Operations cannot be interrupted and each machine can process only one operation at a time. The problem is to find the job sequences on the machines which minimise the makespan, i.e. the maximum of the completion times of all operations(6). The Job Scheduling problem is usually solved by approximation or heuristic methods.

III. ANT COLONY OPTIMIZATION

A. Ant Colony Algorithm

The ant colony algorithm is an algorithm for finding optimal paths that is based on the behavior of ants searching for food.

At first, the ants wander randomly. When an ant finds a source of food, it walks back to the colony leaving "markers" (pheromones) that show the path has food. When other ants come across the markers, they are likely to follow the path with a certain probability. If they do, they then populate the path with their own markers as they bring the food back. As more ants find the path, it gets stronger until there are a couple streams of ants traveling to various food sources near the colony.

Because the ants drop pheromones every time they bring food, shorter paths are more likely to be stronger, hence optimizing the "solution." In the meantime, some ants are still randomly scouting for closer food sources. A similar approach can be used find near-optimal solution to the traveling salesman problem.

Ant Colony optimization can also be used to solve variety of combinatorial optimization problems, particularly suitable for the multipoint and non-deterministic search in the solution space of discrete optimization problems and job scheduling problem etc. Scheduling problem is typical kind combinatorial optimization problem. Suppose that there are m machines and n jobs .

IV . EXPERIMENTAL STUDY

Step1 :Generating the Ants

The number of ants depending on the number of jobs are taken initially and the search is started. Each ant starts searching an optimal sequence beginning with the job number as its number .

First ants always search for sequence starting with job number 1, the second ant always search for a sequence with job number 2 like as the first job. Similarly ant always give a sequence with job number n as the first in it.

Let number of jobs n=4.

Let number of machine m=4.

Machine

Machines / jobs	M1	M2	M3	M4	T_{ij}
J1	4	6	8	10	**28**
J2	7	9	11	5	**32**
J3	3	2	6	4	**15**
J4	8	9	1	3	**21**

Table 1:Process Time

$$\tau_{ij} \leftarrow (1-\rho).\tau_{ij} + \Delta\, \tau_{ij}^{best} \quad \text{--- 1}$$

Step 2: Initialization of pheromone matrix

Next the pheromone matrix has to be initialized. It is referred to the problem as 'τ' matrix. This 'τ' matrix is square matrix of order nxn where 'n' is number of jobs as given in the problem. The pheromone matrix is one which gives the numerical value of the intensity of the pheromone trail remaining in the path i-j. This pheromone matrix helps the ants in deciding which path it has to construct while searching for the optimal solution. All the diagonal element are assigned with 0 since an ant can't go from i^{th} position to i^{th} position. All other elements are assigned to some arbitrary constant.

	P1	P2	P 3	P4
J1	0	0.6815	0.7797	1.0000
J2	0.6587	0	0.7033	0.24
J3	0.2475	0.4012	0	0.5867
J4	0.1223	0.082	0.7957	0

Table 2: Pheromone matrix for 4x4 flow shop scheduling

Step3: Sequence generation by all ants

After the initialization of the pheromone matrix, the ants start constructing the sequence. To decide which job to put first and which job will taken into next, the probability of the selection is done by the following equation(2).

$$\rho_{ij} = (\tau_{ij})^{\alpha}(\eta_{ij})^{\beta} / \sum(\tau_{ik})^{\alpha}(\eta_{ik})^{\beta} \quad \text{-------(2)}$$

Where, 'i' stands for the job that is already fixed by the ant, 'j' stands for not yet scheduled jobs.

'τ_{ij}' Value is taken from the pheromone matrix , η_{ij} is the reciprocal of the total time taken by j_{th} job through all machines

'k' ant number, Let α, β are constants. In our problem α=2, β=3.

The ACO algorithm always find the local optimal but rarely find the global optimal. The optimal sequence produced by 4 ants are and makespan for each sequence

Ant - No	**Optimal Sequence Job s**				**Makespanti me**
1	1	3	4	2	48
2	2	3	4	1	52
3	3	4	1	2	51
4	4	3	1	2	50

Table 3: Different sequences from Ant system

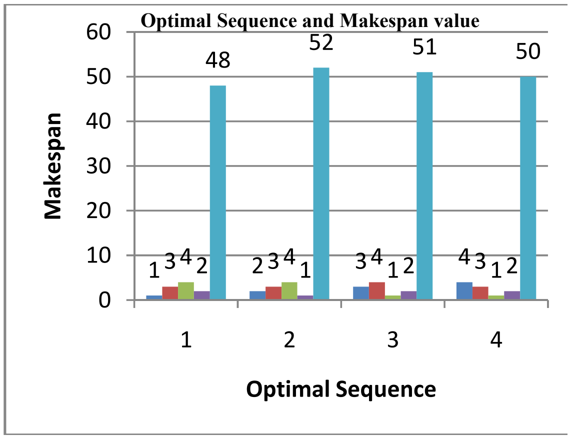

Figure 1 graphical representation of Makespantime. From this above figure, the optimal sequence of 4x4 matrix is 1,3,4,2.

Step4 Calculation of Δτ matrix

Next step is formulation of Δτ matrix. For each ant, a Δτ matrix has to be constructed. The Δτ matrix is a matrix that is used for updating pheromone matrix. This Δτ matrix is constructed for each ant.

Step 5:Updating of pheromone matrix :

The pheromone update equation takes the following form:

The more number of iterations ,give the efficiency of the results obtained and all the optimal sequences are listed out whose output is given as for the low level heuristics.

V. CONCLUSION:

In this paper, an ACO based heuristic to solve the JSP for minimum makespan time criterion is proposed and therefore capable of finding the optimal or near-optimal solutions. ACO can be easily adapted to generate schedules for any scheduling objective of JSP. A future research issue would be to develop hybrid heuristics by incorporating local search techniques, such as PSO and genetic algorithm and tabu search.

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