Emerging Trends of Ant Colony Optimization in Project Scheduling

Samir Thakkar
Department of Computer Applications
Faculty of Science, The MS University of Baroda Vadodara, India

Abstract— Ant Colony Optimization technique as a swarm intelligence technique is based on stigmergy behavior of natural insects. ACO and its variants provided a futuristic and prominent result in the areas of optimization problems. The Paper discusses the Ant Colony Optimization problem. Paper describes ACO metaheuristics as a general framework for finding optimal solution. The paper discusses project scheduling measures and suggests the need of ACO in the other comprehensive areas related to project scheduling. It predicts and concludes with the remarks that ant colony optimization and its metaheuristics can be useful in more comprehensive project management tasks.

Key words: Project Scheduling, Ant Colony Optimization

I. INTRODUCTION

Ant Colony Optimization (ACO) is a technique based on the collective behavior of natural ants which are used to find the shortest possible path by their pheromone evaporation behavior.

Figure 1 shows the stigmergy behavior of the ants and their strategy to find the shortest possible path.

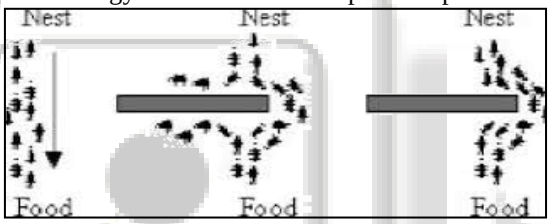

Fig. 1: Ant's Behavior

Every ants starting from their origin travels in search of their food destination. After reaching their destination they evaporate the pheromone in their returning journey. The same behaviour can be followed by the each and every ants based on the pheromone density deposited by their previous ants. As shown in the figure 1 every ants follows the shortest path then after.

ACO algorithms are based on one generic algorithmic model known as ACO metaheuristics which describe the general behavior of ant's algorithms.

II. ACO METHEURISTICS

Metaheuristic can be defined as general set of algorithmic concept that can be used to define heuristic methods which are applicable for the wide set of different problems. The ACO metaheuristic is a particular metaheuristic inspired by the behavior of real ants.

The combinatorial problems are the one which cannot be solved by polynomially bounded time. They are known as NP – hard problems. To solve such NP-hard problems there are some exact algorithm which gives optimal solution at some instance, there are some approximate algorithm which gives exact solution for the optimal solution or near optimal solution. Such algorithm can be stated as heuristic based algorithms.

The general framework of ACO metaheuristic can be described as follows:

```
procedure ACOMetaheuristic
    ScheduleActivities
        ConstructAntsSolutions
        UpdatePheromones
        DaemonActions  % optional
    end-ScheduleActivities
end-procedure
```

Where, ConstructAntsSolutions manages a colony of ants that visit the adjacent states by moving through neighbor nodes of the problem's construction graph. In their movements ants apply a stochastic local decision policy using both pheromone trail and heuristic information. Hence we can say that in this way ants build solutions to the optimization problem.

Once a solution is built up the ant evaluates it and that solution is used in UpdatePheromones procedure. This procedure decides how much pheromone to deposit. Hence, we can say that UpdatePheromone is the process by which the pheromone trails are modified. The trail value can be increased based on the amount of pheromone deposited on the components they use. Pheromone trail can be decreased based on the pheromone evaporation procedure. The deposit of new pheromone increases the probability that those components connections that were either used by many ants or that were used by at least one ant and which produced a very good solution will be used again by future ants.

The DeamonActions procedure, which can be optional, is used to implement centralized actions which cannot be performed by single ants.

ACO metaheuristic is used to solve many NP-hard problems like TSP. Project scheduling is also an example of NP-hard problem which is described in the next section.

III. PROJECT SCHEDULING

Project scheduling considers people intensive activities and their related reports like human resources. Apart from the project task scheduling the problem of human resource allocation plays a major role in project scheduling or software project scheduling.

In [1] Wei-Neng Chen proposed a model for software project planning with the novel approach known as Event Base Scheduler (EBS) and Ant Colony Optimization(ACO). Various scheduling and resource allocation for employee management are also implemented in [2]. In [3] various meta-heuristics based on ACO are considered for resource constrained project scheduling problems. In[4] C.Toley and B.Bhagat also studied software project scheduling with ant colony optimization.

Various project scheduling techniques like Project Evaluation and Review Technique (PERT) and Critical Path Multiplier (CPM) as well as Resource Constrained Project Scheduling Problem Model (RCPSP)[3] have been applied to software project planning. These methods are useful and

helpful in project scheduling but their inadequate in software project scheduling activities as it is people centric activity and assigning the best fitted task to the employee is always difficult task for the project managers. PERT and CPM technique lack the consideration of resource allocation and RCPSP do not consider the allocation of employee allocation and their skills. Mostly routine project scheduling software performs the task scheduling activities only and the human resource allocation to be done by managers manually.

IV. ACO IN PROJECT SCHEDULING

Project scheduling considers people intensive activities and their related reports like human resources. Apart from the project task scheduling the problem of human resource allocation plays a major role in project scheduling or software project scheduling.

Following parameters can be considered vital in terms of project scheduling.

A. Employee Description

Efficient employee description is the foremost task in project scheduling. The problem with the employee allocation is that the suitable task to the employee so that it can be done efficiently. Following parameters should be considered for the employee description.

1) The basic salary of the employee
2) The salary per normal work period
3) The salary for the overtime period
4) Local normal working hour
5) Legal normal working hour
6) Maximum possible working hour per month for the project
7) The skill sets of the employee

B. Task Description

The task description includes efficient timetable for the implementation of tasks which are subject to some precedence constraints. The following parameter should be considered for the task description:

1) The estimated work effort
2) The skill sets required to perform the task
3) The maximum person required to achieve the task
4) The deadline and penalty of the task

The attribute of the employee and task description helps to determine the following objectives:

1) Processing order of the task
2) The working hours of the employee per month must not exceed the limits.
3) The number of employee assigned a task is limited in numbers.
4) All tasks have to complete within assigned time limits.

Ant Colony Metaheursitics can be modeled for project scheduling as follows:

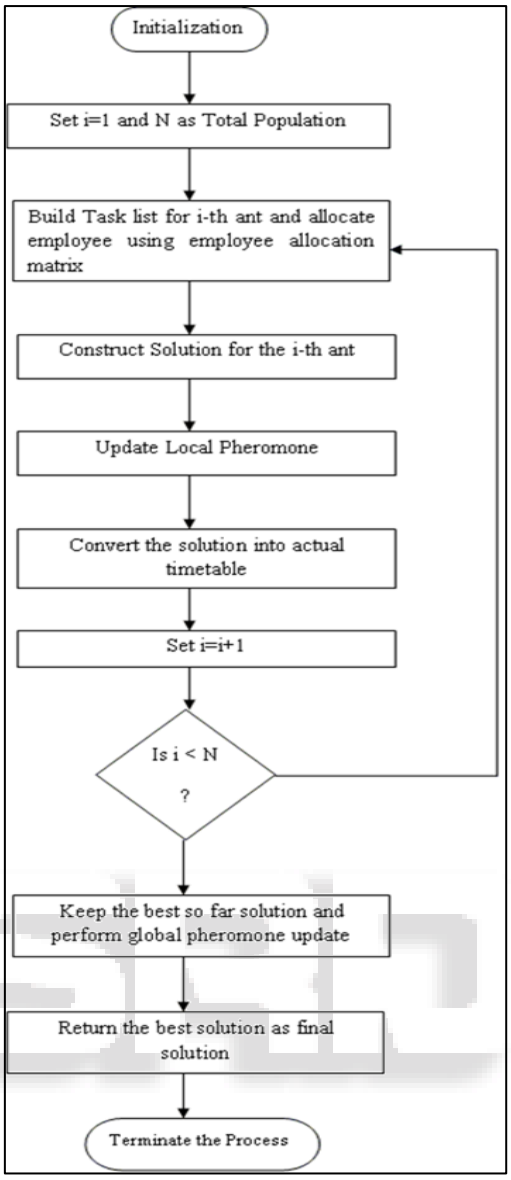

Fig. 2: ACO Model for a Process in Project Scheduling

V. FUTURE ASPECTS OF ACO IN PROJECT SCHEDULING

Previous sections discuss the utilization of ACO metaheuristics in the basic project scheduling activities. It considers basic task scheduling as well as employee criteria for the project scheduling to achieve minimum cost or minimum time as objective function. However, there are many area need to consider that involves various characteristics of project scheduling which can be solved by ACO metaheuristics. The following points to be considered for the future aspects of ACO in project scheduling:

- Employee experience and training criteria should be included to make project more comprehensive.
- More consulting projects need to be considered for the project scheduling.
- Resource allocation should be included in the project management.
- Crashing activities in resource allocation make the task more complicated, such complicated tasks makes the project more comprehensive. Such comprehensive tasks should be included to solve using ACO.

VI. CONCLUSION

Ant Colony Optimization algorithm focuses on self organizing behavior of ants. It is mostly suited and widely applied in the field of optimization. Project scheduling is also such area where ACO metaheuristics is applicable. Paper concludes with the remarks that apart from the basic application parameters of project scheduling one can model the ACO with some more comprehensive tasks by including employee experience and resource crashing activities.

REFERENCES

[1] Wein-Nen Chen.Ant Colony Optimization for Software Project Scheduling and Staffing with an Event Based Scheduler. IEEE.2013;39(1):1-17.
[2] Monica D, Devis S, Subashini D. et al. Scheduling and Resource Allocation for Employees in Software Projects. IJACEN.2014;2(5): 26-19.
[3] Kumar N. Study on meta-heuristics for resource constrained project scheduling problem. IJEMS.2014; 1(2):14-24.
[4] Toley C, Bhagat B. An Application of Ant Colony Optimization for Software Project Scheduling with Algorithm in Artificial Intelligence. IJAIEM.2014; 3(2):149-153.

