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Software Project Planning and Resource Allocation Using Ant Colony Optimization with Uncertainty Handling

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ABSTRACT: In software engineering field, developing software tools is challenging and important. In software project humans are important. Human resources are mainly needed. In software project, planning is important. Since software project is much related to human resource, the human resource allocation is the important problem. A software project planning tool must consider the project planning as well as human resource allocation problem. Also the uncertainty factors can occur. In current approach it develops an event based scheduler and an ant colony optimization. The proposed system represents a plan by task list and employee allocation matrix. In the EBS, the beginning time of the project, the time when resources are released from finished tasks, and the time when employees join or leave the project are regarded as events. For planning and employee allocation ACO is used. In real world projects the uncertain events can occur. Previous models are not much considering about uncertainty. The uncertainty can be considered as an event in event based scheduler. The existing event based scheduler is modified, to include the uncertain events such as unexpected absence of employee, termination of employee. Such uncertain can be handled in the current system.

KEYWORDS: Uncertainty handling; Software project planning; Event Based Scheduler; Resource allocation.

I. INTRODUCTION

Software project management is the art and science of planning and leading software projects [12]. To succeed, companies have to make efficient project plans to reduce the cost of software construction [11]. In large scale project it becomes more complex. In fact, in China it was reported that more than 40 per cent of unsuccessful software projects failed because of inefficient planning of project tasks and human resources [6]. An effective planning tool is important, since an effective plan can reduce cost and time. Since the cost and time are the important factors in software project effective tool can make it success.

A software project planning included the project workload calculation, calculating project work load and cost. It should decide project schedule and resource allocation. The COCOMO [14] model are used to calculate workload and cost estimation.

Uncertainty in software project is an important factor that should be considered. An uncertain event can cause the failure of the current plan. In managing project uncertainty David Cleden explains about, handling uncertainty. The uncertainty arises from deficiencies in knowledge such as contextual information about project, our understanding about underlying process, explanation of past events, and speed of change. Removing uncertainty is costly, because it is time consuming and it uses contingency plan. It can be a trade-off between cost of having uncertainty and damage likely to cause to the project.

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Management of uncertainty is not an independent task, it's the part of project plan. It should be accommodated in the project plan.

The program evaluation and review technique (PERT), the critical path method (CPM) [7], and the resource-constrained project scheduling problem (RCPSP) model are some of the project management techniques, that are applied in software project planning[base]. The main reason is that, differently from other projects, a software project is a people-intensive activity and its related resources are mainly human resources [8]. The human resource allocation is a complex task. Assigning employee to the most suitable task is challenging. Techniques like PERT and CPM lack the consideration of resource allocation and scheduling models like the RCPSP do not consider the allocation of employees with various skills [14].

In Wei-Neng Chen's work [14] he considers the employee allocation problem. The paper introduces a new method EBS for representing allocation of human resources. ACO is used for planning problem. Event based scheduler is a representational scheme. It is the combination of task list [3] and employee allocation matrix [4]. The task list defines the priorities of tasks to consume resources, and the planned employee allocation matrix specifies the originally planned workload assignments [14]. In this way, the representation takes both the issues of task scheduling and resource allocation into account. The EBS regards the beginning time of the project, the time when resources are released from any finished task, and the time when employees join or leave the project as events. To generate an actual timetable, the EBS adjusts the workload assignments of employees at events and resource conflict is solved according to the priority defined by the task list.

In this paper first the literature survey of the related work is done in section 2. In section 3 it explains how the uncertain events can be included in project panning.

II. RELATED WORK

In Chang's work, 'Genetic Algorithm for Project Management' [4], it considers a genetic algorithm for project planning. The scheduling of tasks and the allocation of resource in projects is an extremely hard problem. Even though we have an optimal solution the changing conditions will affect it. Brute force exhaustive or branch-and-bound search methods cannot cope with the complexity inherent in finding satisfactory solutions to assist project managers. In existing project management (PM) techniques, commercial PM tools, and research prototypes in not efficient in computational capabilities and only provide passive project tracking and reporting aids. Project managers must make all major decisions based on their individual insights and experience and must build the project database to record such decisions and produce reports in various formats such as Gantt or Pert charts.

In this paper a new technique was developed based on genetic algorithms (GA) that automatically determines, using a programmable goal function, a near-optimal allocation of resources and resulting schedule that satisfies a given task structure and resource pool[4]. It assumes effort is known, or it calculates from existing models such as COCOMO model.

With the result of the algorithm, the software manager will be able to assign tasks to staff in an optimal manner and predict the corresponding future status of the project which includes an extensive analysis on the time-and cost variations in the solution space. A new GA algorithm is developed which can operate on much more complex scheduling networks involving multiple projects. They also can deal with more realistic programmatic and organizational assumptions. The results of the GA algorithm were evaluated using exhaustive search for five test cases. In this paper a 2D array format is used to represent planning. Array contains one for task and other for employee.

This paper presents a heuristic method, a genetic algorithm (GA), to solve the scheduling problem in project management. It represented the workload assignment in percentage.

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In Yannibelli's 'A knowledge based evolutionary assistant to software development project scheduling' [19], a knowledge-based evolutionary approach is proposed with the aim of assisting to project managers at the early stage of scheduling software projects. Given a software project to be scheduled, the approach automatically designs feasible schedules for the project, and evaluates each designed schedule according to an optimization objective that is priority for managers at the mentioned stage. The objective is to assign the most effective set of employees to each project activity. For this reason, the evaluation of designed schedules in our approach is developed based on available knowledge about the competence of the employees involved in each schedule. This knowledge is from historical information about the employee.

The design of an initial schedule for a software development project is a central, non-trivial and costly task for software companies. This task implies defining feasible start times (i.e., precedence relation must be considered) and feasible human resource assignments (i.e., the resource requirements must be satisfied) for project activities. In addition, to define the mentioned resource assignments, it is necessary to estimate the efficiency of the human resources in relation to different project activities. This is because the development and the results of an activity depend on the affectivity of the resources assigned to it.

For this it uses a process, which is divided into two stages. The first stage determines the positions of the project activities on the activity list. The second stage defines the employees that are assigned to each activity based on the human resource requirements of such activities, i.e., the second stage defines the assigned resources list.

The main advantage also considers the multi skill of employee. The main disadvantage is that it assumes each employee is assigned to each task at a time. Pre-emption is not allowed.

Marco Dorigo proposed a new optimization technique called Ant Colony Optimization (ACO).

In this paper the authors introduced a new computational paradigm called the Ant System, a viable new approach to stochastic combinatorial optimization. The main characteristics of this model are positive feedback, distributed computation, and the use of a constructive greedy heuristic. Positive feedback accounts for rapid discovery of good solutions, distributed computation avoids premature convergence, and the greedy heuristic helps find acceptable solutions in the early stages of the search process. The algorithms they developed are models derived from the study of real ant colonies and are called Ant algorithms.

Here the authors make use of artificial ant colonies as an optimization tool where the ants are agents that possess some differences from the natural ones: Artificial ants will have some memory, they will not be completely blind, and they will live in an environment where time is discrete.

Using these Ant systems the authors have developed Ant algorithms of three kinds-Ant-cycle algorithm, Ant-density algorithm and Ant-quantity algorithm. They then analysed these algorithms for different cases and had summarized the results. They also specified a comparison of the ant system algorithms with other heuristics and found to be effective than others.

III. PROPOSED SYSTEM

In the proposed system, an effective approach can be developed for project scheduling and human resource allocation problem. It also considers the uncertain events handling. The proposed method characterises by two features.

First, a representation scheme, event-based scheduler (EBS) is developing [14]. The representation scheme is composed of project list, task list and a planned employee allocation matrix. The project list defines the priorities of projects to be scheduled. The task list is a set of sets of tasks for each project and it defines the priorities of tasks to consume resources,

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and the planned employee allocation matrix specifies the originally planned workload assignments. In this way, the representation takes both the issues of task scheduling and resource allocation into account. The EBS regards the beginning time of the project, the time when resources are released from any finished task, and the time when employees join or leave the project as events. To generate an actual timetable, the EBS adjusts the workload assignments of employees at events and resource conflict is solved according to the task duration and priority defined by the task list. In this way, the proposed scheme is practical and flexible as it enables the modelling of task pre-emption and resource conflict. The proposed scheme reduces the size of the search space and thus accelerates the search process. In addition, as the EBS only makes new assignments at events, it is able to keep the implementation of tasks in a more stable manner.

Second, different from the GA and TS approaches developed in the existing studies, an ACO approach is proposed here. ACO was proposed by Dorigo and Gambardella in the early 1990s and by now has been successfully applied to various combinatorial optimization problems. As ACO builds solutions in a step-by-step manner and enables the use of problem-based heuristics to guide the search direction of ants, it is possible to design useful heuristics to direct the ants to schedule the critical tasks as early as possible and to assign the project tasks to suitable employees with required skills. Therefore, ACO promises to converge fast and perform well on the considered problem.

The uncertain events can be handled here as events. When an uncertain event occurs, the completed task and currently available human resource are calculated and form a new plan with the existing resources.

A. Event Based Scheduler

Similar to the work of Chen's [14] here it combine the task list representation and the employee allocation matrix representation so that both the problems of task scheduling and human resource allocation are addressed.

$$\begin{aligned} &\text{Task list} : (t_{p1}, t_{p2}, \ldots, t_{pn}) \\ &\text{Planned Employee Allocation matrix} : \begin{cases} pwh_{11} pwh_{12} \ldots\ldots\ldots pdwh_{1n} \\ \ldots\ldots \ldots\ldots \ldots\ldots \ldots\ldots \\ pwh_{m1} pwh_{m2} \ldots\ldots\ldots pwh_{mn} \end{cases} \end{aligned} \quad (1)$$

Fig.3.1 Combined task list and employee allocation problem

The EBS is characterized by making new assignments at events. It considers time t as an event if t will be one of the following conditions: 1) t = 1 is the beginning of the project, 2) time of leaving or joining of any employee or 3) any task just finished in the previous time period and the corresponding resources become released and available at t. The EBS adjusts a plan in the form of (1) into an actual timetable by some rules. One of the rule is resource conflict between two tasks, the task that appears earlier in the task list has a higher priority to use the resource.

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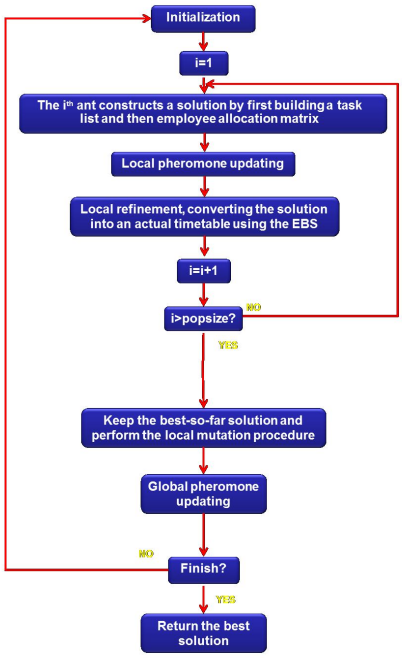

Fig 3.2: Flow chart of system.

B. Ant Colony Optimization

The underlying idea of ACO is to simulate the foraging behaviour of ants. When ants search for food, they usually deposit a special chemical on the path they travel through. This kind of chemical, which is called pheromone, serves as a medium for ants to communicate with each other. By sensing the concentration of pheromone, other ants can follow the path to find the food. Inspired by this swarm intelligence phenomenon, ACO was developed by Dorigo et al. [4], [5] and has been successfully applied to various optimization problems. An ACO algorithm works by dispatching a group of artificial ants to build solutions to the problem iteratively. In general, an ACO algorithm can be viewed as the interplay and the repeated execution of the following three main procedures [14]:

1. Solution construction

During each iteration of the algorithm, a group of ants set out to build solutions to the problem. Each ant builds a solution in a constructive manner by selecting components step by step to form a complete solution. The selections are made according to pheromone and heuristic information. In ACO, pheromone is a record of the past search experience of ants for guiding the following ants to make decisions. The components belonging to the best solutions found by the previous ants usually accumulate more pheromone, attracting more ants to select in future iterations. Heuristic is some problem-dependent information that helps ants to have higher probabilities to select promising components in the solution construction procedure.

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2. Pheromone management

Along with the solution construction procedure, pheromone values are updated according to the performance of the solutions built by ants. Ants tend to deposit more pheromone to the components of better-performed solutions.

2. Daemon actions

Daemon actions mean the centralized operations that cannot be done by single ants. In the design of ACO algorithms, daemon actions are optional, but many existing ACO variants use different kinds of daemon actions to improve performance. One commonly seen daemon action is the local search procedure.

The ACO will develop an optimized plan, in the form of matrix, from all the iterations. And from that plan the EBS will develop schedule based on events. When an uncertain event occurs the remaining resource will be calculated, also the remaining tasks to complete. And again a new schedule will be developed according to it. It can also consider uncertainty at the starting phase. And we can allow some space for it. As a representational plan [10].

IV CONCLUSION AND RESULT

Computer Aided technique for planning software project is important and challenging. Effective plan can reduce cost and also time needed. In software project main resources are human resources. Human resource allocation is a complicated task. The models with large search space restrict the flexibility in human resource allocation. For the scheduling it should considers staff with different skills. In real world projects the uncertain events can occur. Previous models are not much considered about uncertain events. The uncertainty can be considered as an event in event based scheduler. An event based scheduler can be extended to include uncertain events.

The current schedule generated for a 6 task in a project with 7 employees is generated as shown in fig 3.1

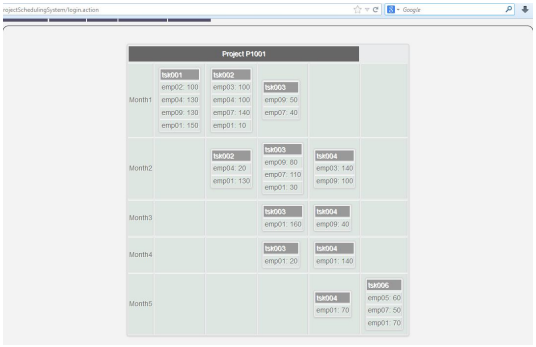

Fig 4.1: Schedule of Task

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