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# Review on Computer Aided Techniques for Software Project Scheduling and Staffing

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## ABSTRACT

Software development organizations frequently resist distributing projects on time, within the resources and with the required quality. The problem is due to reduced quality of software project management and particularly, insufficient in project scheduling and ineffective in staffing process. Scheduling the software projects is important and challenging for software project managers. An efficient project plan reduces the software construction cost and reduces the completion time. Efficient resource allocation influences the project execution. So, an adequate model for software project planning and resource allocation is necessary. This study shows the survey about various approaches with different scheduling algorithms and optimization techniques currently in use and their applicability to the software engineering. The comparative analysis of the optimization technique shows that the Hybrid optimization algorithm gives better results when compared to other techniques.

**Key words:** Software project planning, project scheduling, resource allocation, staff assignments, optimization algorithm

## INTRODUCTION

Software project managers play the vital role in the end product of software. Software project managers take responsibility for some or all of the following activities: Proposal writing, project planning and scheduling, project cost, project monitoring and reviews, personnel selection and evaluation, report writing and presentation. Project management deals with many phases: Definition, planning, executing, control and closure of project (Sommerville, 2010). Among those phases, an interesting issue is project scheduling and resource allocation in the planning phase. Scheduling is the process where tasks in the project are ordered to execute by the time.

Resource allocation is the process where available resources in the project are assigned in order to execute the given task. Scheduling and allocations are usually complex depending on constraints and factors considered in a project. The project schedule is the core of the project plan. It is used by project manager to commit people to the project and show the organization, how the work will be performed. Schedules may be used to determine number of resources needed to complete the project. They are also used as a kind of checklist to make sure that every task necessary is performed. Staff assignments are done by the project managers based on the skills and availability. Companies will be succeed, by making efficient project plans which reduces the software construction cost (Nan and

Harter, 2009). The task scheduling problem has been solved for years and is known to be NP complete (Chiang *et al*., 2006). Software project managers frequently employ scheduling to perform preface time and resource estimates, general assistance and analysis of project alternatives (Gerasimou *et al*., 2012). Initially customer can contact the management. If management decides to work on the product, they can communicate with project manager who further share their ideas with developer. Software project may be a failure due to the inadequate and unsuitable practices regarding schedule and staff assignments activities followed by software project managers.

Assigning the right task to the right person is a challenging job for project manager. To solve the resource allocation problem, the author designed a Taguchi's parameter with preemption rules and scheduling heuristics are employed. Taguchi's parameter design contains two portions: An inner array which containing the controllable factors and an outer array containing noise factors. Controllable factors are human resources and noise factors are complexity of project.

Project performance is measured using project duration which is calculated from combination of inner array and outer array. Which combination produces low project duration and low cost, the managers considers that combination of list and apply. Here the tasks are interrupted if the resources are not available and restarted when the resources are available (Lee, 2007).

Traditional models and tools for project management techniques required being comprehensive. Search-based optimization problem is the remarkable approach for software project planning. For the period of the last decade, the thought of planning software engineering as search-based problems has increasing attention (Clarke *et al*., 2003; Harman *et al*., 2009). Various software engineering actions such as cost estimation (Aguilar-Ruiz *et al*., 2001), module clustering (Praditwong *et al*., 2011), design (Simons *et al*., 2010), testing (Harman and McMinn, 2010), (Garousi, 2010) and software release planning (Ngo-The and Ruhe, 2009) have been modeled as search-based problems and meta heuristic algorithms have been applied effectively.

Kolisch and Hartmann (2006) affirmed different techniques for project scheduling which was not paying attention on software engineering. Search based Software Project Planning (SBSPP) comprises of approaches like genetic algorithms and simulated annealing correspond to the best search based techniques in terms of performance for scheduling and staffing problem.

Ramaswamy (2000) applied queuing theory to form software maintenance projects. Podnar and Mikac (2001) performed simulations of software maintenance for the function of estimating different process strategies rather than staffing the system.

Performance engineering technique was introduced by Bertolino *et al*. (2007) based on the usage of queuing models and UML performance profiles which assist project managers for decision making in teams and tasks. The search based techniques developed by Bertolino *et al*. (2007) suggested to managers that the configuration capable to minimize the completion time and exploit the efficiency in resource usage.

The selection scheduling and staffing problem is nonlinear supposed by Gutjahr *et al*. (2008). The objective function aggregates two terms: Project gain and global company efficiency improvement over the scheduled time span and consider the employee skills and talents. Real values are assigned to skills and abilities, probable changing over time. Projects are formed by tasks and each task is decomposed into one or more work packages. A work package is a logical unit needed deterministic and known effort of a single competence. Then, the problem is solved by means of different heuristics, that is Ant Colony Optimization (ACO) and GAs combined with a problem-specific greedy technique.

There have been a number of approaches planned over the years that intend to helping software project managers choose on various technical factors such as project duration and attempt

with developer availability, with most of the techniques proposed tackling scheduling and staffing as an optimization problem. Many researchers have paying attention on using techniques as computational intelligence, as these have been proven to be very efficient for solving real-world problems that are large in size and high in complexity. The techniques include evolutionary algorithms (Alba and Chicano, 2007; Ren *et al*., 2011), fuzzy logic (Callegari and Bastos, 2009) and constraint satisfaction (Barreto *et al*., 2008).

In this study, a survey is taken regarding a practical and effective approach for the task scheduling and human resource allocation problem in software project planning.

## MATERIALS AND METHODS

Constraint Logic Programming (CLP) was proposed by Barreto *et al*. (2005) for scheduling and staffing problem which was not based on the idea of search based optimization. The CLP focuses on conveying maintenance requests to the majority of qualified team or to the team consisting of highest productivity. To this aim, they assumed the survival of a relationship between completion time and developer skills which was not empirically sustained by data from real projects. As an alternative, the authors showed a tool for the manager which schedules the project improved.

Software development constantly faces unforeseen events like changes in technology, platform, environment and market requirements. Therefore, uncertainty is a challenge to calculate approximately the project cost and schedule. To deal with the challenge, Event Chain Methodology (ECM) is proposed by the author in recent years to model risk events separately from activities. It makes known that how events interact with each other and affect activities in project. This study examines the uncertainty nature of events and activities in ECM and presents fuzzy set theory to expand ECM modeling capability. The Fuzzy-ECM (FECM) model is then used for measuring project schedules by simulation, sampling and interpolation. Case studies are carried out to demonstrate the proposed approach (Jian-Hong *et al*., 2011).

The Project Scheduling Problem (PSP) is also defined as an optimization problem which is presented during the process of scheduling the software project. Previous study Parra *et al*. (2012) the author discuss about the single objective problem that occurs due to scheduling the software projects. A set of meta heuristics with a Hybrid approach is introduced by the author to schedule the software projects by reducing the cost and the duration of the entire processes. As this approach is examined with a number of instances of the software projects with the various developers to know their performance and their working ability.

In the study of Chen and Zhang (2013) a novel approach with an Event-Based Scheduler (EBS) and an Ant Colony Optimization (ACO) algorithm were presented by the author for software project planning. The presented approach had shown a plan by seeing the task list and the well planned employee allocation matrix. By this way, both the problems of task scheduling and employee allocation were to be considered. In the EBS, the commencement time of the project, the time when resources are released from completed tasks and the time when employees join or leave the project are observed as events. The fundamental idea of the EBS is to adjust the allocation of employees at actions and maintain the allocation unchanged at non actions. With this approach, the presented approach facilitates the modeling of resource variance and task preemption and conserves the flexibility in human resource allocation. To overcome the planning issues, an ACO algorithm is additionally considered. Table 1 shows the overall survey summary.

Table 1: Overall survey summary

| Authors | Algorithms |
|---|---|
| Gerasimou *et al*. (2012) | Particle Swarm Optimization (PSO) algorithm is presented to assist with software system project managers |
| Gutjahr *et al*. (2008) | Portfolio selection scheduling and staffing problem: ACO and GA |
| Barreto *et al*. (2005) | Constraint Logic Programming (CLP) aimed at assigning maintenance requests |
| Jian-Hong *et al*. (2011) | Project Scheduling Problem (PSP) is also defined as an optimization problem Ant Colony Optimization (ACO) Metaheuristic Algorithm |
| Chen and Zhang (2013) | Event-Based Scheduler (EBS) and an Ant Colony Optimization (ACO) algorithm |

Table 2: Performance comparison of the optimization techniques using convergence behavior

| Iterations | GA | ACO | Hybrid optimization approach |
|---|---|---|---|
| 0 | 4.00 | 3.50 | 3.00 |
| 10 | 2.95 | 2.75 | 2.20 |
| 20 | 2.80 | 2.60 | 2.10 |
| 30 | 2.75 | 2.55 | 1.80 |
| 40 | 2.65 | 2.40 | 1.65 |
| 50 | 2.55 | 2.35 | 1.40 |
| 60 | 2.50 | 2.25 | 1.40 |
| 70 | 2.10 | 1.65 | 1.40 |
| 80 | 1.90 | 1.65 | 1.40 |
| 90 | 1.80 | 1.65 | 1.40 |
| 100 | 1.80 | 1.65 | 1.40 |

Table 3: Performance comparison of the optimization techniques using processing time

| Optimization algorithms | Processing time (sec) |
|---|---|
| GA | 21 |
| ACO | 18 |
| Hybrid optimization approach | 10 |

## RESULTS AND DISCUSSION

The performance of the optimization algorithm is evaluated based on the parameters like:

- Convergence behavior
- Processing time

**Convergence behavior:** Table 2 shows the performance comparison of the optimization techniques such as Genetic algorithm, ACO and the Hybrid algorithm.

The Hybrid optimization algorithm like, PSO_GA, PSO_ABC etc., outperforms the GA algorithm and ACO algorithm in attaining the reliability in terms of convergence behavior.

Figure 1 shows the comparison of the convergence behavior of the GA, ACO and the Hybrid optimization approach. It is observed from the figure that the Hybrid converges in lesser iterations when compared with the other optimization techniques. For instance, the GA approach takes 90 iterations for convergence, ACO approach takes 70 iterations whereas the Hybrid optimization approach takes 40 iterations for convergence, thus the Hybrid optimization technique is very significant when compared with the other optimization approaches taken for consideration.

**Processing time:** Table 3 shows the performance comparison of the optimization techniques such as Genetic algorithm, ACOs and the Hybrid optimization approach.

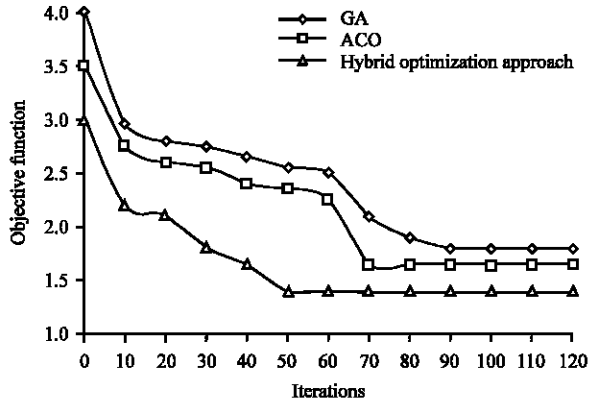


Fig. 1: Comparison of convergence behavior

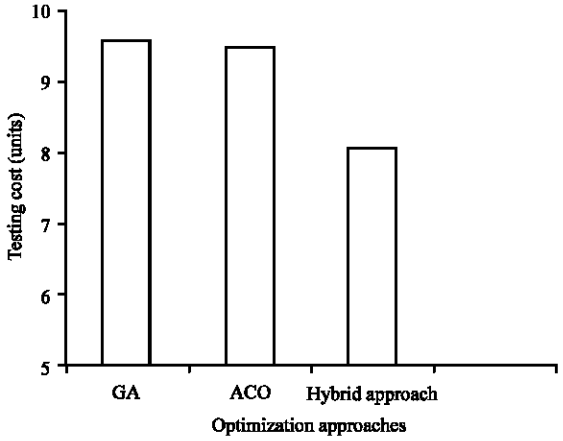


Fig. 2: Comparison of testing cost

The Hybrid optimization algorithm outperforms the GA and ACOs algorithm in attaining the reliability in terms of the processing time.

It is observed from the Fig. 2 that the Hybrid optimization technique takes processing time of 10 sec, whereas the other optimization techniques such as GA and ACOs take longer processing time such as 21 and 18 sec, respectively.

The experiments are evaluated based on some other parameters like reliability, testing cost and the run time. The Hybrid optimization approach is compared with Traditional single-objective approaches. Table 3 shows that the comparison of various approaches. From the Table 3, it is shown that the Hybrid optimization approach is more efficient in solving the problems of resource allocation in the software products etc., than the other existing approaches.

From the Fig. 2, 3 and 4 it is observed that the Hybrid optimization approach is more efficient than the other existing approaches.

Finally, it is concluded that the Hybrid optimization approaches gives better results in the field of software project planning and scheduling.

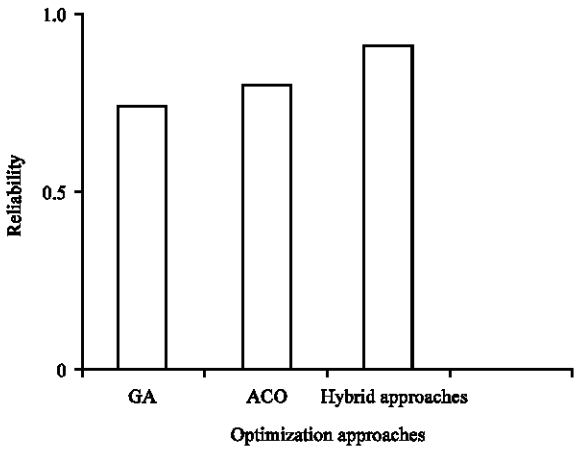


Fig. 3: Comparison of reliability

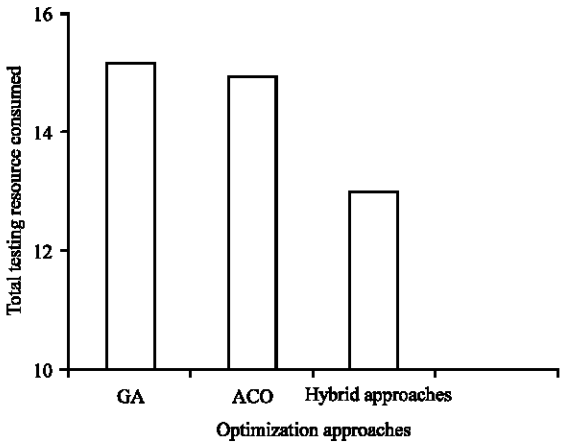


Fig. 4: Comparison of total testing resource consumed

## CONCLUSION

Software project scheduling and staffing is one of the most important tasks for Software project management. Project scheduling refers to the planning and scheduling of the projects/tasks. Project scheduling consists of many activities. Staffing is a term used in the sphere of employment. Some activities of the project are very critical that delay the overall project completion time. Major rework or project failure will be the result of wrong scheduling and staff assignment. By adopting effective software project scheduling technique and resource assignment every software project manager can manage the software development efficiently. In this study, a review of some of these software project scheduling techniques is done using various research papers in this field. Various type of scheduling techniques which are used in software projects are discussed. This review of various techniques will be helpful for better study and inventing new ideas for even better scheduling techniques.

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