

A Review of Genetic Algorithm used for optimizing scheduling of Resource Constraint construction projects

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Abstract - Optimizing construction project scheduling has received a considerable amount of attention over the past twenty years. Planning and scheduling is important role in construction projects because of the increasing complexities in this field. Construction Planning is the necessary warning to Scheduling and determining general sequence, defining labor tasks, construction methods and assigning responsibilities. Inappropriate planning can lead to major delays in the project work. Resource-Constrained Project Scheduling Problem (RCPS) considers limited resources availability and duration of activities and required resources, linked by sequence relations. The problem consists of finding a schedule of minimal duration by assigning a start time to each activity such that the constraints like precedence, resources are described. This article reviews genetic algorithm is an optimization technique is developed to optimize the schedule of construction project by the various researchers.

Key Words: Scheduling, Planning, Optimization, Genetic Algorithm, Resource constraint.

1. INTRODUCTION

The construction scheduling is to complete the project in time and equal the resources with the allocated time . Every project schedule has its own precedence constraints, which means that each activity can be processed when all its predecessors are finished. In general the purpose of project scheduler is to minimize its completion time or duration, subject to precedence constraints. Resources such as tools, equipment, machines, or labor are needed for one or more activities at same time. Each resource has limited capacity; consequently at a certain moments one activity may not begin their processing due to resource constraints even if all their predecessors are finished, [14]. This type of problems is called Resource-constrained project scheduling problem (RCPS) which involves assigning jobs or tasks to a resource or a set of resources with limited capacity in order to meet some predefined objective, [4]. This problem type aims at minimizing the total duration or makespan of a project subject to precedence relations between activities and limited renewable resource availabilities. Since the late

1950s, the Critical Path Method CPM and the program Evaluation and Review Technique PERT have been intensively used for planning and controlling large-scale projects in the construction industry,[7]. However, CPM considers the precedence relations between the activities and unlimited resources during scheduling of projects. RCPS problems are analyzed using algorithms to bring a harmony between time and cost trade off. Genetic algorithm (GA) is a method used for solving optimization problems that is based on natural selection, the process that drives biological evolution.

This paper provides a review of Genetic algorithm that has been developed to address the RCPS problem.

1.2 GENETIC ALGORITHM

The optimization technique genetic algorithm (GA) is technique of optimization based on the principle of natural selection. The theory of natural selection by Charles Darwin forms the base of the genetic algorithm. Over several generations, biological organisms evolve based on the principles of natural selection "survival of the fittest",[4]. Genetic algorithms (GAs) were invented by John Holland in the 1960s and were developed by Holland and his students and colleagues at the University of Michigan. GA is an evolutionary algorithm that use techniques inspired from evolutionary biology such as mutation, selection and crossover,[13].

2. LITERATURE REVIEW

T. Hegazy (1999) in his paper proposed improvements to resource allocation and leveling heuristics, and the Genetic Algorithms (GAs) technique is employed to search for optimum solution. To reduced the moment of the resource histogram around the horizontal axis (time), GA considered resource leveling and allocation.

In his studies, Three main developments were created with respect to improving the resource management of projects: (1)An effective improvement to resource allocation heuristics using random activity priorities; (2)heuristics

using a double –moment approach for a practical modification to resource leveling and (3)the Genetic algorithm is used for a multiobjective optimization of both resource allocation and leveling. Using widely used project management software, a macro program was written to automate the GA procedure and a case study was used to demonstrate its benefits and future improvements and extensions.

Khlaed(2001) noted that for repetitive construction projects such as highways, high-rise buildings, and housing projects, duration and cost of project is minimize due to Optimizing resource utilization . This can be achieved by identifying an optimum crew size and disruption strategy for each activity in the project. He developed model for repetitive construction projects is based on a dynamic programming formulation, designed to identify an optimum crew formation and interruption option for each activity in the project that leads to minimum project duration. The model incorporates a scheduling algorithm and an intermission algorithm

Toklu (2002) introduced a computer program to apply GA in order to schedule resource constrained projects to minimize make span. The strategy of solving a problem took a lot of time; a project consists of only eight activities was solved after one thousand generations, and took six minutes in a computer having Pentium III-500 processor.

He presents chromosomes represent schedules with temporal variables, i.e., with start dates. Adopting this time-oriented representation increases the importance of the two mathematical operators introduced in this study, namely the datum operator and the left compression operator. These operators actually perform the similar duty as the forward pass in CPM. Because of the willingness of remaining as natural as possible, the left compression operator is not used in this analysis. Instead, a local search operator is introduced, which has a natural mutational meaning.

A. B. Senouci(2004) presents an augmented Lagrangian genetic algorithm model for resource scheduling. They consider all precedence relationship multiple crew strategies, total project cost minimization, and time-cost trade-off for the development of model. In the new formulation, resource leveling and resource-constrained scheduling are performed simultaneously. The model presented uses the quadratic penalty function to transform the resource-scheduling problem to an unconstrained one. The presented hybrid genetic algorithm model complements the traditional CPM approach by optimizing project schedule and total cost as it performs resource leveling. He concludes that the developed model is capable of handling a wide range of project sizes including large construction projects involving a large number of activities.

J. MAGALHAES(2008) proposes a genetic algorithm for solving the resource constrained project scheduling

problem. The chromosome representation of the problem is based on random keys. The schedule is constructed using a heuristic priority rule in which the priorities and delay times of the activities are defined by the genetic algorithm. The developed model was tested on a set of standard problems taken from the literature and compared with other approaches. The computational results validate the effectiveness of the proposed algorithm.

Leonidas Sakalauskas (2009) Applications of information technologies are frequently connected to making some schedules, timetables of tasks or jobs with constrained resources. He takes into account algorithms of job scheduling associated with resources, time, and other constraints. Schedule optimization procedures, based on schedule coding by the priority list of jobs, are created and investigated.

In his paper, he analyzes the genetic algorithm based on the job priority list. Population forming, construction of operators for crossover, mutation and selection using the job priority list will be introduced and investigated. He conclude that of jobs with resource constraints, based on schedule coding by the job priority list and the serial priority list decoding procedure This kind of schedule coding generally allows us to apply several heuristic optimization methods. Genetic algorithm has been investigated and compared by statistical modeling, while using data sets and known solutions from the PSP Library.

Tahreer (2010) adopt a new approach to develop in generating the populations of the genetic algorithms generations; that is the “Feasible Solutions Developer operator; (FSD operator). This operator enables the user to produce completely feasible solutions that satisfy all constraints and this helps in getting a quick convergence toward the best solution during GA stages, without losing the GA feature of searching global maximum or minimum. Also, a new crossover operator was developed in her study; the procedure of the new crossover operator suit the scheduling problem formulation, and suit the type of the used chromosomes. She compares genetic algorithm result with MSP and CPM for minimization of duration for completion of projects in two real time project as a case study. And the result shows the developed optimization model meet the intended goal of achieving the best schedule with the minimum efforts.

Dr. Mohammed (2011) concludes that Genetic algorithm program is easily using for smooth resources and then compares with MS-Project when the GA results are better than MS-Project. Three case studies have been applied in this research and the application results come identical with research objectives, to form the conclusion. The proposed model is formulated Using C++ program, the proposed model is formulated for resource smoothing. The Genetic Algorithms (GAs) model developed in C++ program to find the optimum solution.

Devikamalam (2013) in her paper say that resource allocation and leveling are among the top challenges in project management, due to the complexity of projects. The main objective of her project is to optimize the schedule of construction project activities in order to minimize the total cost with resource constraints using Genetic Algorithm (GA optimization technique). She describes a genetic algorithm approach to Resource Constraint Project Scheduling Problems (RCPSP) in construction industry in her work. Using Genehunter, the GA procedure searches for an optimum set of tasks and priorities that minimum project duration.

She concludes that an implementation of the GA developed model for resource-constrained project scheduling has resulted in optimized output with reduced cost. A real time project solved using this optimization software shows that best converging result can be obtained.

N Kumar(2014) explains that resource management ensures that a project should be completed on time, at cost, and its quality is as previously defined; nevertheless, the scarcity of resources is a usual reason for project delays. Traditional analytical and heuristic approaches are inefficient and inflexible when solving construction resource leveling problems. In this method, the activity selected first for shifting is based on the largest value of resource rate. The process is repeated for all the remaining activities for possible shifting of resources by searching the optimal solution by the Genetic Algorithm. The GA procedure searches for optimum outcome in set of tasks and priorities that produce shorter project duration and better using MS Excel Evolver software. He developed GA model for project scheduling of resources for leveled use has resulted in optimized output with reduced cost.

Rajeevan and Nagavinothini (2015) state that resource constraints project scheduling problem is one of the most intractable problems in Operations Research and it has recently become a popular area for the latest optimization techniques. For the resource constraint project scheduling, the meta-heuristic algorithm of optimization complements the traditional CPM approach and MSP software for scheduling by optimizing project schedule. The project results show that the algorithm is able to find the best known solutions from the problems space. Further researches have to be done regarding the early convergence of GA and also in handling highly complex problem. The importance of project scheduling under in future as the limitation on resources will be tighter, hence we expect In future the limitations will be tighter , so the importance of project scheduling under resource constraints problems will increase, hence to see better portion of the project scheduling literature developing around the various project scheduling under resource constraints problems.

Hussain (2015) stated that resource allocation and leveling is one of the top challenges in construction project

management, due to complex nature of the construction projects. CPM and PERT is not capable of minimizing undesirable fluctuations in resource utilization profile. He used procedure in his paper finds an optimum set of tasks and priorities that generate better-leveled resources profiles using Genetic Algorithm in MATLAB software.

Merine Saji (2015) describes a Genetic algorithm approach to resource leveling and allocation in construction industry. In this study resource leveling problem is developed using genetic algorithm (GA) in MATLAB software. She proposes Genetic Algorithm as optimization techniques because to optimize a unimodal function, there is many other techniques which can work efficiently and faster than "Genetic Algorithm" but for complex multimodal problems with a frequent change in nature the Genetic Algorithm are the best choice for optimization. This technique may be slow but robust in nature and confirm produce the possible best solution for optimization.

From this model it is observed that the total construction cost is reduced even though the duration increases. A real time project solved using this optimization software shows that best converging result can be obtained. It is hoped that the implementation of this model justifies the efforts in saving the project cost.

3. CONCLUSIONS

Scheduling is the important part of the project planning and it is affected by resource availability, budget, and duration. Limited resources are one of the common constraints observed in all the projects and it affects a constructor's ability to execute and deliver a project as originally planned. There is a need to develop the most optimum method to schedule a project keeping the resources as constraint.

Computer programs give adequate solutions but, when resource requirements exceed the resources available, the computer programs do not provide the optimum scheduling solutions. In genetic algorithm, scheduling problems are not well-defined constraints these are often difficult problems. This are not easily possible to represent using traditional math and thus susceptible to entrapment in suboptimal regions of the search space. Genetic algorithms avoid sub-optimal solutions of the general resource- constrained scheduling problems.

In this paper, we broadly reviewed that many researcher have used Genetic Algorithm for resource constraint project scheduling and have compared results with MSP and Primavera results and they conclude that GA gives the appropriate optimal and feasible solution.

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