World Academy of Science, Engineering and Technology
International Journal of Industrial and Systems Engineering
Vol:11, No:07, 2017

Multi-Criteria Evolutionary Algorithm to Develop Efficient Schedules for Complex Maintenance Problems

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Abstract : This paper introduces an extension to the well-established Resource-Constrained Project Scheduling Problem (RCPSP) to apply it to complex maintenance problems. The problem is to assign technicians to a team which has to process several tasks with multi-level skill requirements during a work shift. Here, several alternative activities for a task allow both, the temporal shift of activities or the reallocation of technicians and tools. As a result, switches from one valid work process variant to another can be considered and may be selected by the developed evolutionary algorithm based on the present skill level of technicians or the available tools. An additional complication of the observed scheduling problem is that the locations of the construction sites are only temporarily accessible during a day. Due to intensive rail traffic, the available time slots for maintenance and repair works are extremely short and are often distributed throughout the day. To identify efficient working periods, a first concept of a Bayesian network is introduced and is integrated into the extended RCPSP with pre-emptive and non-pre-emptive tasks. Thereby, the Bayesian network is used to calculate the probability of a maintenance task to be processed during a specific period of the shift. Focusing on the domain of maintenance of the railway infrastructure in metropolitan areas as the most unproductive implementation process at construction site, the paper illustrates how the extended RCPSP can be applied for maintenance planning support. A multi-criteria evolutionary algorithm with a problem representation is introduced which is capable of revising technician-task allocations, whereas the duration of the task may be stochastic. The approach uses a novel activity list representation to ensure easily describable and modifiable elements which can be converted into detailed shift schedules. Thereby, the main objective is to develop a shift plan which maximizes the utilization of each technician due to a minimization of the waiting times caused by rail traffic. The results of the already implemented core algorithm illustrate a fast convergence towards an optimal team composition for a shift, an efficient sequence of tasks and a high probability of the subsequent implementation due to the stochastic durations of the tasks. In the paper, the algorithm for the extended RCPSP is analyzed in experimental evaluation using real-world example problems with various size, resource complexity, tightness and so forth.

Keywords : maintenance management, scheduling, resource constrained project scheduling problem, genetic algorithms
Conference Title : ICCIE 2017 : International Conference on Computers and Industrial Engineering
Conference Location : Stockholm, Sweden
Conference Dates : July 13-14, 2017