Proceedings of the International Conference on Industrial Engineering and Operations Management
Manila, Philippines, March 7-9, 2023

Integrated Team Planning and Maintenance Scheduling for Geographically Distributed Assets

Aza Al Riyami, Hakan Gultekin, Emad Summad
Department of Mechanical and Industrial Engineering
College of Engineering,
Sultan Qaboos University
Muscat, Oman
s103055@student.squ.edu.om, hgultekin@squ.edu.om,
esummad@squ.edu.om

Abstract

Maintaining Geographically Distributed Assets (GDA) requires complex team planning and scheduling decisions. Recently, many approaches have been introduced in the literature to solve this complex optimization problem. However, most of the introduced optimization models in the literature have considered this problem in its simplest form without involving realistic features such as precedence constraints, temporal dimension, and multiple depots. Therefore, the developed solutions are unlikely to be applicable in real-life systems. This study aims to determine the optimal number of teams and their schedules over a planning horizon to minimize the total cost associated with performing a group of maintenance activities in GDA. We formulated the problem as a Mixed Integer Linear Programming (MILP) model, which considers the release dates, due dates, interdependencies, teams working hours, and assets availability. The model is a more realistic variant of the multi-depot multi-period vehicle routing problem. As far as we know, this is the first study to consider all these features simultaneously.

VRP is a well-known NP-Hard problem; therefore, we developed a novel hybrid metaheuristic algorithm to solve large practical instances of the problem. We combined Genetic Algorithm with a problem-specific solution encoding with a Simulated Annealing algorithm (GASA) to facilitate the search. We implemented the MILP model in IBM CPLEX OPL and coded GASA in Python. We performed an extensive computational study to test the performance of the proposed solution methods. The results over 600 instances revealed that GASA has a stable behavior dealing with different levels of the problem's complexity, including the number of activities, assets, depots, days, teams, and interdependent activities. The MILP model is solved with a one-hour time limit. For the problem instances optimally solved by MILP, GASA provided solutions with an average error of 0.13%. Furthermore, when the MILP model was stopped due to the time limit, GASA produced an average of 4.4% better solutions than MILP. GASA was able to solve all instances in reasonable solution times. The performance of GASA was also demonstrated by real-life case studies of GDA maintenance systems of one of the leading companies in the energy sector in Oman. The results proved the effectiveness of GASA by generating solutions with an average of 39% less than the actual paid cost and 94% faster than the time spent on planning. The cost reductions in several instances reached up to 50%. The case study proved that the proposed GASA model is a promising tool to reduce the operational cost of the business and, accordingly, increase the company's profits.

Keywords
Team Planning, Maintenance Scheduling, Geographically Distributed Assets, Vehicle Routing Problem, Hybrid Genetic Algorithm and Simulated Annealing

Biographies
Hakan Gultekin is an Associate Professor at the Department of Mechanical and Industrial Engineering, Sultan Qaboos University, Muscat, Oman. He received his BS, MS, and PhD degrees in Industrial Engineering from Bilkent University, Turkey. His research interests include scheduling, optimization modeling, and exact and heuristic

algorithm development, particularly for problems arising in modern manufacturing systems, energy systems, transportation and logistics, and wireless sensor networks.

Emad Summad is an Assistant Professor at the Department of Mechanical and Industrial Engineering, Sultan Qaboos University, Muscat, Oman. Emad Summad has a Ph.D. in Industrial Engineering. He specializes in policy issues for entrepreneurship and innovation in the knowledge-based economy. Dr. Summad's research interest is on new perspectives on the adoption and diffusion of innovations, using agent-based modeling to understand what happens when innovations are adopted by individual consumers and diffused in aggregate markets. His work also includes innovation ecosystem orchestration mechanisms & partner selection for open innovation. He promotes technology-based lean startups.

Aza Al Riyami received the B.Sc Degree in industrial engineering from Sultan Qaboos University in 2017. Currently, she is a M.Sc student in Industrial Engineering at Sultan Qaboos University. Her master’s thesis focuses on the optimization problems of team planning and scheduling.