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Electronic Notes in DISCRETE MATHEMATICS

Electronic Notes in Discrete Mathematics 58 (2017) 239–246 www.elsevier.com/locate/endm

Clustering approach in maintenance of capillary railway network

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Abstract

Maintenance optimization of railway infrastructure includes several kinds of aspects, such as safety, economic, operational, organization and regulatory issues. Among them the regulatory issues, that are fixed, increase the maintenance costs significantly. This is especially true in so-called capillary networks (local regional railway networks), where only the freight transport exists. Hence, the question is how to minimize maintenance costs with respect to regulatory issues? To solve this problem, we propose a clustering approach. The idea is to cluster tracks, considering elements of railway infrastructure as attributes. Once railway tracks are clustered in groups with similar attributes, then the maintenance can be organized more efficiently. In this paper, Variable Neighborhood Search metaheuristic is developed to solve minimum sum of squares clustering problem. Based on the results of clustering and available real and simulated data we report 22% savings in maintenance schedule for clusters.

Keywords: Maintenance, railway infrastructure, optimization, minimum sum of squares, variable neighborhood search.

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http://dx.doi.org/10.1016/j.endm.2017.03.031

1 Introduction

In the past, railway maintenance procedures have been traditionally planned based on the knowledge and experience of each company, accumulated over many decades of operation, with the major goal of providing a high level of safety to the infrastructures, without much concern over the economic issues [4]. But, according to the standards, maintenance is a "combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function" [5]. Also, there are many aspects of maintenance that can be the subject of optimization, including decisions regarding maintenance intervals, balance of corrective and preventive maintenance, grouping of maintenance activities, and the timing of maintenance and renewal [14]. The academic literature presents a range of methods for optimization and decision support for maintenance of critical infrastructure, but so far, these have rarely been adopted by the studied industries, and also did not treat the regulatory issues.

In this paper we take into account regulatory issues as one of really important aspect of railway maintenance optimization. The regulatory issues are fixed, and they are defined by national safety railway law, then by national safety rules, by standards and by internal rulebooks of the railways companies. This chain increases the maintenance costs significantly. This is especially true in so-called capillary networks (local regional railway networks), where only the freight transport exists. Now, the question is how to minimize maintenance costs with respect to regulatory issues? To solve this problem, we propose a clustering approach. The idea is to cluster tracks, considering elements of railway infrastructure as attributes. Once railway tracks are clustered in groups with similar attributes, then the maintenance can be organized more efficiently. Several variants of Variable Neighborhood Search (VNS) metaheuristic are developed to solve minimum sum of squares clustering problem such as: VNS-j-means, VNS-$j-h-k$-means, Variable Neighborhood Descent VND-$k-h$-means and VND-Nested $j-h-k$-means. Based on the results of clustering and available real and simulated data we report 22% savings in maintenance schedule for clusters.

The remainder of this paper is organized as follows. Section 2 describes the considered clustering problem with the attributes for classification. VNS variants for classification are explained in Section 3. Furthermore, in Section 4 present our VNS for the preventive maintenance scheduling problem. Finally, Section 5 is devoted to our conclusions.