A Flexible Integer Linear Programming Formulation for a Class of Bus Driver Rostering Problems

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Abstract

In this work is present a novel integer linear programming formulation to solve an operation planning problem in public transport systems. The proposed model is flexible, and it works by adding or removing specific constraints for the operation, depending on the laws of the corresponding country and the policies of a particular company. The formulation proposed in this work models a generic version of the *Bus Driver Rostering Problem,* which has a considerable amount of issues to be considered, mostly due to the complexity of the personnel management and their assignment of the daily duty. The main issues taken into account in the model are the specific work conditions, labor regulations for each country, companies' internal policies and available staff. These are included as sets of hard constraints of the problem. In the literature, it was observed that there is a lack of general mathematical models representing this class of problems. Consequently, most of the published research related to this problem concern the development of heuristic solutions. Moreover, two-phase hybrid approaches combining heuristic and exact methodologies, for the first and second stage, respectively, are not able to ensure optimal solutions. In this study, the model is tested on three different scenarios: (i) benchmark instances, (ii) newly proposed benchmark instances simulating the operation of a transport company varying the types of shifts and available staff, and (iii) real case of a public transport company of a Bus Rapid Transit (BRT) system in Colombia. Computational experiments show that a mixed integer programming (MIP) solver is capable of obtaining optimal solutions for each of the aforementioned scenarios in reasonable computing times.

Keywords
Rostering, Operational Planning, Mathematical Formulation and Crew Scheduling.

Biographies

Kenny Cárdenas Parra has a degree in Industrial Engineering from the Technological University of Pereira, Colombia (2019) and he is currently doing his M.Sc. in Operations Research at the same university. He is currently one of the main researchers in the Group TransFÓRMATE, which belongs to Integra S.A., operator of the BRT system in Pereira Colombia. He has experience in scheduling and rostering problems for bus drivers.

César Augusto Marín-Moreno is the Manager of the R+D+i department at Integra S.A, the operator of the massive transit system in the city of Pereira, Colombia. He recently completed his Ph.D. in the Technological University of Pereira (2019), working problems oriented to Tactical and Operational Planning. He is expert in project formulation and PMP certified.

Rubén Iván Bolaños. is currently the Development Coordinator of Integra S.A. Ph.D. student at the Technological University of Pereira, working Vehicle and Crew Scheduling Problems, and Rostering for BRT (Bus Rapid Transit) operators.

Luis Miguel Escobar-Falcón has a degree in Computer Science Engineering (2007) and a M.Sc. degree in Electrical Engineering (2012) from the Technological University of Pereira, Colombia. He has a Ph.D. in Engineering (2019) in the same university, having his abroad period in the University of Bio-Bio, Chile and the University of Bologna, Italy (2016). Currently is the Research Coordinator of Integra S.A, operator of the Bus Rapid Transit System of Pereira, Colombia, and Professor in the Program of Systems Engineering of The Free University in the same city. Has experience working and implementing solutions for operations research problems such as Packing Problems, Vehicle Routing Problems and Scheduling Problems.

Mauricio Granada-Echeverri, Professor of the Technological University of Pereira on subjects of electrical engineering, he has a Ph.D. on Electrical Engineering from the Sao Paulo State University (UNESP, Brazil). He has almost 20 years of experience on operations research, combining electrical planning problems with optimization, and also classic logistics problems.