Districting based on Stochastic Demands

Eduardo Díaz Medina
Facultad de Ingeniería
Universidad Panamericana
Zapopan, Jalisco 45010, Mexico
ediazm@up.edu.mx

Samuel Nucamendi-Guillén
Facultad de Ingeniería
Universidad Panamericana
Zapopan, Jalisco 45010, Mexico
snucamendi@up.edu.mx

Rosa González Ramírez
Facultad de Ingeniería y Ciencias Aplicadas
Universidad De Los Andes
Santiago, Chile rgonzalez@uandes.cl

Neale R. Smith-Cornejo
Industrial Engineering Department
Tecnológico de Monterrey
Nuevo León, 64670, Mexico nsmith@itesm.mx

Abstract

This study proposes a mathematical model and a hybrid metaheuristic (based on Greedy Randomized Adaptive Search Procedures and Tabú Search) for the distribution districting problem considering stochastic demand. The problem is inspired by a situation faced by a parcel company operating in Monterrey, Nuevo León México. The company desires to develop a strategic plan to district customers in pursuit of accomplishing two objectives: 1) balancing the average workload between districts (by minimizing the maximum workload content in a district), 2) creating compact districts, which is modeled as the minimization of the maximum distance between a pair of points in a district. . In González-Ramírez et al. (2017). As an extension and to incorporate the stochasticity of demand, we proposed to consider several representative days. We propose a single-objective optimization model in which we optimize the normalized weighted sum of the two objectives. As we are considering several demand scenarios, the proposed model minimizes the weighted sum of the maximum average workload content of each district (average over the demand days) and the compactness metric measured as the maximum time between the farthest away pair of points of a district. In order to normalize the parameters, we estimate the optimal allocation of workload among districts and the optimal compactness metric assuming a circular shape of districts. Furthermore, it is very important that the workload of the districts respect a maximum service time. Otherwise, the company has to pay extra time to the drivers. Given that this is a soft constraint, we model it as a third term in the objective function, penalizing the exceeding workload content of each demand day and district. The proposed model was implemented in C++ and solved via CPLEX. Since it could be difficult to solve large instances to optimality, a multi-start hybrid metaheuristic is also developed, combining elements of GRASP and Tabu Search. At the construction phase, to generate multiple solutions, three heuristics to select a set of seeds are defined. The first heuristic selects the seeds among the most dispersed points. The second is based on a sweep algorithm, and the third one is very similar but considers the workload of each point. For each of the seed

methods, a GRASP structured is implemented, randomly selecting the seeds from a restricted candidate list. Once the seeds have been selected, the remaining points are assigned to the districts that are closest and that are connected in the graph by an arc (which refers to the adjacency matrix of the graph). With an initial solution constructed the second step considers a local search procedure in which the movements consider moving points between adjacent districts under a Tabu Search structure.

Preliminary results confirm the fact that the model presents limitations regarding the size of the scenarios solved, whereas the metaheuristic obtains high-quality solutions for larger instances in a reasonable amount of time.

Keywords:
Districting, Distribution, Mixed-Integer Formulations, Metaheuristics, Demand-Scenarios.

References

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Eduardo Díaz-Medina. Eduardo Díaz-Medina has a bachelor degree in Industrial Engineering. He is specialist in Operations Management, awarded by Universidad Panamericana. His professional experience involves the veterinary pharmaceutical and automotive industries. Since 2019 Eduardo works as a coordinator for the general vice rector's office for research. Currently, Eduardo is coursing the Master in Engineering, at Universidad Panamericana.

Samuel Nucamendi-Guillén is an Associate Professor, working for the Operations Research Department, at the Faculty of Engineering, in the Universidad Panamericana, Mexico. He has a Master in Science in Quality and Productivity Systems, and a Ph.D. in Engineering awarded by Tecnologico de Monterrey. He had a research stay at Universidad de La Laguna in Tenerife, Spain, working with a group of intelligent computing. He has the Black Belt certification in Six Sigma by Breakthrough Management Group International (BMGI). He worked as a lecturer at Facultad de Ciencias Físico Matemáticas at UANL. His industrial professional experience is in the manufacturing and telecommunications industries. Since 2012, he is a member of the Mexican Society of Operations Research and since 2017 is a member of the National System of Researchers.

Rosa G. González Ramírez is an Assistant Professor at the Faculty of Engineering and Applied Sciences of the Universidad de Los Andes Chile. She holds a bachelor's degree in industrial engineering, a master's degree in industrial engineering, a master's degree in quality systems and productivity and a PhD in engineering sciences from Monterrey Tech in Mexico. She has published in several scientific journals and conferences, as well as divulgation magazines. Her research areas are logistics and transport of cargo, maritime shipping and port operations, supply chain management and optimization.She has received several research grants in Chile from the government of Arica and Valparaiso as well as other funding agencies. She is currently collaborating with several ports in Chile to analize their operations and propose decision making support models and algorithms for container handling. She is leading a group of professionals in ports and logistics in Latin America and the Caribbean (LAC), and participated from 2014-2019 in the program Digital Network of Collaborative Ports in LAC. She has served as Secretary at the Board of the Chilean Institute of Operations Research, and she is currently the Secretary at the Board of the Mexican Society of Operations Research.

Neale Smith-Cornejo. Neale R. Smith is an associate professor at the Tecnológico de Monterey within the National School of Engineering and Sciences where he currently directs the Doctoral Program in Engineering Sciences and a research group in Optimization and Data Science. He holds an undergraduate degree in Industrial Engineering from the University of Arizona and M.S. and Ph.D degrees in Industrial Engineering from Georgia Tech. He has taught both undergraduate and graduate level courses in operations research, logistics and supply chain management. His research interests are in the areas of applied optimization and logistics and he has advised 23 M.S. and six PhD theses. He has over 40 peer reviewed publications and a Mexican patent. Before pursuing an academic career, he was a consultant and implemented logistics-related solutions for numerous companies.