PROCEEDINGS OF THE EUROPEAN WORKING GROUP ON LOCATION ANALYSIS MEETING 2015

Edited by
B. G.-Tóth and K. Kovács
Budapest University of Technology and Economics
EWGLA is a Working Group devoted to Locational Analysis within EURO, the Association of European Operational Research Societies. It was born during the first EURO Summer Institute, held at Brussels, July/August 1984, devoted to the subject of Location Theory. At that time the main aim of starting up the Working Group was to provide a network of people working together and to keep continuity in the exchanges between the Summer Institute’s participants. Since that time the group has known important growth and broadened its scope and purpose. Friendship among its members continues however to play an important role.

The subjects of interest to the group are of many kinds, centering on the optimal choice of locations for one or more objects (usually called facilities), within any framework (the classical settings being discrete, network and planar). Many other fields have direct connections with location analysis and location theory, either by subject such as transportation and routing, supply chain management, environmental studies, layout and design, data and cluster analysis, or as techniques, like mathematical (linear, integer, non-linear, convex, global, ...) programming, multi-criteria analysis, approximation theory, computational geometry, statistics, etc.

This 22nd meeting of EWGLA, being held on May 20th-22th, 2015, at the Corvinus University of Budapest, Hungary, intends to gather the operations research community from different parts of the world to share experiences in the field of locational analysis.

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Contents

Preface ii

Program 1

Plenary Talks

Santo Fortunato
Community structure in complex networks 11

Leo Liberti
Euclidean Distance Geometry and applications 13

Abstracts

M. Albareda-Sambola, Elena Fernández, and Francisco Saldanha da Gama
Solutions to the Facility Location Problem with General Bernoulli Demands 17

M. Albareda-Sambola, M. Landete, J.F. Monge, J.L. Sainz-Pardo
The Reliability Fixed-Charge Location Problem with capacity constraints 19

M. Albareda-Sambola, L. I. Martínez-Merino, and A. M. Rodríguez-Chía
The probabilistic $p$-center problem 21

S. A. Alumur, S. Nickel, B. Rohrbeck, F. Saldanha-da-Gama
Different Allocation Models for Hub Location Problems with Congestion 23
<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi-period hub network design problems with modular capacities</td>
<td>S. A. Alumur, S. Nickel, F. Saldanha-da-Gama and Y. Seçerdin</td>
</tr>
<tr>
<td>Location Routing on Trees</td>
<td>Julian Araoz and Elena Fernandez</td>
</tr>
<tr>
<td>P-graph Framework: Computer Aided Model Generation and Solution for Supply Network Optimization Problems</td>
<td>Aniko Bartos and Botond Bertok</td>
</tr>
<tr>
<td>Covering Location Problems on Networks with Edge Demand</td>
<td>Oded Berman, Jörg Kalcsics, and Dmitry Krass</td>
</tr>
<tr>
<td>A Branch&amp;Bound Methodology for Locating Multiple Facilities on Networks</td>
<td>R. Blanquero, E. Carrizosa, B. G.-Tóth and A. Nogales-Gómez</td>
</tr>
<tr>
<td>A mathematical programming model for the organization of a transfusion system in a regional context</td>
<td>G. Bruno, C. Piccolo, G. Romano, A. Genovese and M. Barbati</td>
</tr>
<tr>
<td>Post Disaster Damage Assessment with Unmanned Aerial Vehicles</td>
<td>Elfe Buluc and Bahar Y. Kara</td>
</tr>
<tr>
<td>Solving the Absolute $p$-Center Location Problem on Large Networks</td>
<td>Hatice Calik, Bahar Y. Kara, and Barbaros C. Tansel</td>
</tr>
<tr>
<td>Location of Rectangles for Graphs Visualization</td>
<td>Emilio Carrizosa, Vanessa Guerrero, and Dolores Romero Morales</td>
</tr>
<tr>
<td>Hedging uncertainty in the shelter site location problem</td>
<td>I. Correia, B. Yetiş Kara, Ö. Burak Kinay, F. Saldanha-da-Gama</td>
</tr>
<tr>
<td>Green Location Routing Problem</td>
<td>Okan Dukkanci, and Bahar Yetis Kara</td>
</tr>
</tbody>
</table>
Contents

Gergely Kovács, and Béla Vizvári
Exact Models for Open Field Layout Problem with $l_2$ and $l_1$ Distances

Kristóf Kovács, Boglárka G.-Tóth
Stackelberg location problems on networks with operational costs

Rui Borges Lopes, Carlos Ferreira, and Beatriz Sousa Santos
Heuristic Approach for Solving a Dynamic and Stochastic Location-Routing Problem

M.C. López-de-los-Mozos, Juan A. Mesa
The Maximum Trip Covering Conditional Location Problem on Tree Networks

Vladimir Marianov, Gabriel Gutiérrez-Jarpa, Carlos Obreque
p-Cable Trench Problem with Covering

Alfredo Marín
Discrete Optimization in Map Labeling: An overview and foresight

Mozart B.C. Menezes, Giovanni J.C. da Silveira, and Renato Guimarães
Social Network Influence on Demand and its Impact on Forecast Accuracy

Merve Meraklı, Hande Yaman
Robust Hub Location Under Polyhedral Demand Uncertainty

Juan A. Mesa, Francisco A. Ortega, Miguel A. Pozo
Locating Multi-Hydrants in Water Irrigation Networks by using Expected Distances

Panagiotis Mitropoulos, Ioannis Mitropoulos, Ioannis Giannikos
Planning health services in primary care: A stochastic location allocation model

Hozumi Morohosi and Takehiro Furuta
A Statistical Model Analysis of Urban Ambulance System and its Application to Location Problems
Preventive Health Care Facility Location Planning with Quality-Conscious Clients
Sven Müller, Knut Haase, and Ralf Krohn
89

An Efficient Heuristic Algorithm for the Alternative-Fuel Station Location Problem
Gábor Nagy and Trung Hieu Tran
91

The Multi Shift Coverage Facility Location Problem
Andreas Nearchou and Ioannis Giannikos
93

Locating Park + Ride Nodes in an Agglomeration: Issues, Methodologies, Criteria
Jan W. Owsiński, Jarosław Stańczak, Krzysztof Sęp
95

Network design of electricity transmission systems with renewable energy sources
Meltem Peker and Bahar Y. Kara
97

On $k$-centrum optimization with applications to the location of extensive facilities on graphs and the like
Justo Puerto, Antonio M. Rodríguez-Chía
99

Capacitated Mobile Facility Location
S. Raghavan, Mustafa Sahin, and Sibel Salman
101

Tactical Network Planning for Food Aid Distribution in Kenya
M.È. Rancourt, J.F. Cordeau, G. Laporte and B. Watkins
103

Cournot-Stackelberg Games in Competitive Delocation
Diego Ruiz-Hernandez, Javier Elizalde, and David Delgado-Gómez
105

Periodic Location Routing Problem: An Application of Mobile Health Services in Rural Areas
Sinem Savaşer, Bahar Yetiş Kara, Hünkar Tuyoğlu
107

Quintile Share Ratio in a linear city
Ken-ichi Tanaka and Takehiro Furuta
109
Christian Trinks, Hannah Schmidt, Fabian Stenzel, Andreas Hornung
Analysis and optimization of digestate supply networks in Bavaria 111

Takamori Ukai and Mihiro Sasaki
Relationships between Demand-and-Supply Balance Indecies and
Unfairness Minimization 113

Béla Vizvári
Towards the Exact Solution of Industrial Design Problems 115

Ryosuke Yabe, Yudai Honma and Shigeki Toriumi
Optimal combination of road blocking for improving evacuation
time from tsunami 117

Baris Yildiz, Okan Arslan, and Oya Ekin Karasan
A Branch and Price Approach for Routing and Refueling Station
Location Problem 119

Elif Zeynep Serper and Sibel A. Alumur
The Design of Capacitated Intermodal Hub Networks with Differ-
ent Vehicle Types 121

Author Index 124

Topic Index 131
PROGRAM
Wednesday May 20th

8:30 – 9:00  Registration

9:00 – 10:00  Application 1

Takamori Ukai: Relationships between Demand-and-Supply Balance Indecies and Unfairness Minimization 113
Laureano Escudero: On location modeling in Energy Generation Capacity and Transmission Extension Planning 47

10:00 – 10:20  Coffee Break

10:20 – 12:00  Layout and continous optimization

Andrea Maier: Library of Location and Layout Algorithms (LoLoLA) and Urban Event Planning 59
Béla Vizvári: Towards the Exact Solution of Industrial Design Problems 115
Gergely Kovács: Exact Models for Open Field Layout Problem with $l_2$ and $l_1$ Distances 67
Ken-ichi Tanaka: Quintile Share Ratio in a linear city 109

10:20 – 12:00  Application 2

Gábor Nagy: An Efficient Heuristic Algorithm for the Alternative-Fuel Station Location Problem 91
Sven Müller: Preventive Health Care Facility Location Planning with Quality-Conscious Clients 89
Jan W. Owsiński: Locating Park + Ride Nodes in an Agglomeration: Issues, Methodologies, Criteria 95
Meltem Peker: Network design of electricity transmission systems with renewable energy sources 97

12:00 – 13:00  Lunch

13:00 – 14:40  Discrete location 1

Diego Ruiz-Hernandez: Cournot-Stackelberg Games in Competitive Delocation 105
Francisco A. Ortega Riejos: Locating Multi-Hydrants in Water Irrigation Networks by using Expected Distances 83
Mercedes Landete: The Reliability Fixed-Charge Location Problem with capacity constraints 19
Sergio Gracía: A Lagrangian Approach for the Stochastic $p$-Median Problem 57

14:40 – 15:00  Coffee Break

15:00 – 16:40  Location under uncertainty

M.A. Garín: On the strongest Lagrangean bounds for stochastic location-assignment problems 49
Maria Albareda-Sambola: Solutions to the Facility Location Problem with General Bernoulli Demands 17
Ömer Burak Kinay: Hedging uncertainty in the shelter site location problem 43
Panagiotis Mitropoulos: Planning health services in primary care: A stochastic location allocation model 85

20:00 –  Boat tour in the Danube
Thursday May 21th

9:00 – 10:00  Plenary Talk

Leo Liberti: Euclidean Distance Geometry and applications 13

10:00 – 10:20  Coffee Break

10:20 – 12:00  Hub location

Brita Rohrbeck: Different Allocation Models for Hub Location Problems with Congestion 23
Francisco Saldanha-da-Gama: Multi-period hub network design problems with modular capacities 25
Hande Yaman: Robust Hub Location Under Polyhedral Demand Uncertainty 81
Sibel Alumur Alev: The Design of Capacitated Intermodal Hub Networks with Different Vehicle Types 121

10:20 – 12:00  Application 3

Mozart B.C. Menezes: Social Network Influence on Demand and its Impact on Forecast Accuracy 79
Marie-Ève Rancourt: Tactical Network Planning for Food Aid Distribution in Kenya 103
Yudai Honma: Optimal View Points for Fireworks Displays with Respect to Solid Angles 65
S. Raghavan: Capacitated Mobile Facility Location 101

12:00 – 13:00  Lunch

13:00 – 14:40  Discrete location 2

Alfredo Marín: Discrete Optimization in Map Labeling: An overview and foresight 77
Antonio M. Rodríguez-Chía: The probabilistic $p$-center problem 21
Emilio Carrizosa: Location of Rectangles for Graphs Visualization 41
Justo Puerto: On $k$-centrum optimization with applications to the location of extensive facilities on graphs and the like 99
13:00 – 14:40  Location and routing 1

*Elfe Buluc*: Post Disaster Damage Assessment with Unmanned Aerial Vehicles  37

*Baris Yildiz*: A Branch and Price Approach for Routing and Refueling Station Location Problem  119

*Philipp Hessler*: Extended Sink Location Problems  63

*Ryosuke Yabe*: Optimal combination of road blocking for improving evacuation time from tsunami  117

14:40 – 15:00  Coffee Break

15:00 – 16:40  Network location

*Dmitry Krass*: Covering Location Problems on Networks with Edge Demand  31

*Hatice Calik*: Solving the Absolute $p$-Center Location Problem on Large Networks  39

*Rafael Blanquero*: A Branch&Bound Methodology for Locating Multiple Facilities on Networks  33

*Kristóf Kovács*: Stackelberg location problems on networks with operational costs  69

20:00 –  Optional dinner
Friday May 22th

9:00 – 10:00    Plenary Talk

Santo Fortunato: Community structure in complex networks

10:00 – 10:20   Coffee Break

10:20 – 12:00   Location and supply chain


Giuseppe Bruno: A mathematical programming model for the organization of a transfusion system in a regional context

Christian Trinks: Analysis and optimization of digestate supply networks in Bavaria

Olivier Péton: Multi-directional local search for a sustainable supply chain network design model

10:20 – 12:00   Covering models

Hozumi Morohosi: A Statistical Model Analysis of Urban Ambulance System and its Application to Location Problems

Ioannis Giannikos: The Multi Shift Coverage Facility Location Problem

M.C. López-de-los-Mozos: The Maximum Trip Covering Conditional Location Problem on Tree Networks

Vladimir Marianov: p-Cable Trench Problem with Covering

12:00 – 13:00   Lunch

13:00 – 14:40   Location and routing 2

Nazli Esen: The Demand- Selective Location Routing Problem: the School Districting Application

Okan Dukkanci: Green Location Routing Problem

Elena Fernández: Location Routing on Trees
Rui Borges Lopes: Heuristic Approach for Solving a Dynamic and Stochastic Location-Routing Problem

14:40 – 15:00 Coffee Break

15:00 – 16:15 Location Routing and Scheduling

Marton Frits: Planning and Scheduling Aircraft Missions by P-graphs to Eliminate Empty Legs

Corinna Heßler: The Discrete Parallel Machine Makespan Scheduling-Location Problem

Sinem Savaşer: Periodic Location Routing Problem: An Application of Mobile Health Services in Rural Areas

16:20 – 17:00 EWGLA Session

19:00 – Gala Dinner
PLENARY TALKS
Community structure in complex networks

Santo Fortunato

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Complex systems typically display a modular structure, as modules are easier to assemble than the individual units of the system, and more resilient to failures. In the network representation of complex systems, modules, or communities, appear as subgraphs whose nodes have an appreciably larger probability to get connected to each other than to other nodes of the network.

In this talk I will address three fundamental questions:

- How is community structure generated?
- How to detect it?
- How to test the performance of community detection algorithms?

I will show that communities emerge naturally in growing network models favoring triadic closure, a mechanism necessary to implement for the generation of large classes of systems, like e.g. social networks. I will discuss the limits of the most popular class of clustering algorithms, those based on the optimization of a global quality function, like modularity maximization. Testing algorithms is probably the single most important issue of network community detection, as it implicitly involves the concept of community, which is still controversial. I will discuss the importance of using realistic benchmark graphs with built-in community structure.
Euclidean Distance Geometry
and applications

Leo Liberti

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Quite aside from the obvious relationships between Euclidean Distances and locational analysis, the fundamental problem of Distance Geometry, called DGP, is essentially a location problem, namely: given an integer $K$ and a weighted simple undirected graph $G = (V, E)$, find positions $x_1, ..., x_n$ in $\mathbb{R}^K$, where $V$ counts $n$ vertices, such that, for each edge $\{u, v\} \in E$, the Euclidean distance between $x_u$ and $x_v$ is precisely the weight associated to the edge. Many variants relax the equality to pairs of inequalities, or even single sense inequalities. We introduce the Branch-and-Prune (BP) algorithm, a Fixed-Parameter Tractable algorithm which can find all incongruent solutions to a given DGP instance amazingly fast and reliably.
ABSTRACTS
Solutions to the Facility Location Problem with General Bernoulli Demands

M. Albareda-Sambola, Elena Fernández, and Francisco Saldanha da Gama

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Keywords: discrete location, stochastic programming, heuristic

In this work we address the facility location problem with general Bernoulli demands. Extended formulations are proposed for two different outsourcing policies, which allow using sample average approximation for estimating optimal values. In addition, solutions are obtained heuristically and their values compared with the obtained estimates. Numerical results of a series of computational experiments are presented and analyzed.

1. Facility Location with Bernoulli Demands

The Facility Location Problem with Bernoulli Demands (FLPBD) is a discrete facility location problem where the demands of the customers are independent random variables following a Bernoulli distribution. That is, a set of potential customers is given but, after the location and assignment decisions are made, only a subset of them will actually have to be served. Facilities locations have to be chosen among a finite set of sites, each having associated a fixed set-up cost and a capacity. If, after the demands are revealed, the capacity of a facility is not sufficient to serve all its allocated customers with demand, then the facility resorts to outsourcing incurring an extra cost.
The goal is to decide what facilities to open and allocate each potential customer to an opened facility in such a way that the sum of set-up costs plus the expected service and outsourcing costs is minimized.

The FLPBD was first presented in [1]. That work focuses on the homogeneous case, i.e., the case where the probability of having demand is the same for all the customers. For this case, the paper gives a closed form for the recourse function (expected service plus outsourcing cost) and a compact formulation of the deterministic equivalent problem, that allows solving the problem in reasonable times. Here we address the general case when demand probabilities need not be the same.

2. Solution Algorithms

We present a heuristic for the FLPBD based on path relinking. In an initial step, solutions are generated using a GRASP procedure, where the constructive phase focuses on plant selection and the local search on customers assignment. Path Relinking is then applied to a pool of elite solutions. Throughout the algorithm cost approximations are used, since the evaluation of feasible solutions to the FLPBD is computationally expensive.

Alternatively, estimates of optimal values and good quality solutions are obtained via sample average approximation. This requires extended formulations where scenarios are explicitly considered. Such formulations with tractable sizes are proposed for two alternative outsourcing policies.

The numerical results obtained with both algorithms are presented and analyzed. For the particular case with homogeneous demand the results are compared with the optimal solutions given by the exact algorithm of [1].

References

The Reliability Fixed-Charge Location Problem with capacity constraints

M. Albareda-Sambola, 1 M. Landete, 2 J.F. Monge, 2 J.L. Sainz-Pardo 2

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Keywords:  discrete location, reliability models, capacitated facility location

Reliable facility location models are increasingly being studied in the discrete facility location literature, since they allow to make strategic decisions that, without too large increases in the regular operating costs, prevent the systems from severe deteriorations when facilities fail. This type of models where first proposed in [1], where the authors analyzed the extensions of the classical $p$-center problem and $p$-median problem that are obtained when facility failure probabilities are taken into account, but the number of facilities that can fail is fixed. However, these models were not very much studied until some years later, restarting with [3]. The reader is referred to [2] for a survey on early works concerning this type of models.

We consider a fixed-charge facility location problem with unsplittable demands. Facilities can fail with homogeneous probability, and these failures occur independently. For each customer, a sequence of assignments to opened facilities is defined and, at each scenario, the customer is served from the first facility in the sequence that has not failed. An extra dummy facility, which never fails and has very large assignment costs, is used to model situations where a customer is either lost or outsourced. Capacity constraints on the facilities are stated as hard constraints for the scenario where no failures occur, but relatively small violations are allowed when failures occur.

In this work we propose several formulations for the problem of considering capacities in the Reliability Fixed-Charge Location Problem. Let $X_j$ be the location variables, $Y_{ijr}$ the allocation variables ($Y_{ijr}$ takes value
1 when facility \( j \) is the \( r \)-th closest open facility to demand customer \( i \), \( Q_j \) the capacities, \( h_i \) the demands, \( u \) the extra dummy facility and \( q \) the probability of failure. One naive formulation consists on bounding the expected demand by the capacity. Namely, it consists on adding these two constraints to the Reliability Fixed-Charge Location Problem formulation

\[
\sum_{i \in I} h_i \sum_{r \in R} q^r Y_{ijr} \leq Q_j X_j \quad \forall j \in J \\
\sum_{i \in I} Y_{iu0} = 0
\]

Then, we impose different constraints for the different steps of the sequence of assignments. We give a bound for the expected excess of the capacity and we analyze the linear relation for modeling the expected excess of the capacity in terms of certain known values. Finally, we perform an extensive computational study comparing the optimal solution of all the considered formulations.

**References**


The probabilistic $p$-center problem*

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Keywords: $p$-center problem, probabilistic

This work deals with an extension of the $p$-center problem where the aim is to minimize the expected maximum distance between any user and his center, taking into account the probabilities that demand occurs at each of the given sites. The problem is of interest when locating emergency centers. We propose different formulations for the problem and extensive computational tests are reported, showing the potentials and limits of each formulation on several types of instances. Finally, some improvements on these formulations have been developed obtaining in some cases much better resolution times.

1. Introduction to the problem

The $p$-center problem (pCP) is a well-known discrete optimization location problem which consists of locating $p$ centers out of $n$ sites and assigning (allocating) the remaining $n-p$ sites to the centers so as to minimize the maximum distance (cost) between a site and the corresponding center, see [1, 2]. It was shown in [2] that pCP is NP-hard.

*Thanks to Spanish Research projects: MTM2012-36163-C06-05 and MTM2013-46962-C2-2-P
A straight application of the pCP is the location of emergency services like ambulances, hospitals or fire stations, since the whole population should be inside a small radius around some emergency center. pCP has been extensively studied, and both exact and heuristic algorithms have been proposed.

In this work we focus on the Probabilistic p-Center Problem (PpCP), an extension of the pCP with uncertainties. In general terms, uncertainties in location problems can be classified into three categories: provider-side uncertainty, receiver-side uncertainty, and in-between uncertainty. The provider-side uncertainty may capture the randomness in facility capacity, the reliability of facilities, etc.; receiver-side uncertainty is associated with randomness in demands; and in-between uncertainty may be due to randomness in travel times, transportation costs, etc.

The uncertainty considered in the PpCP is in the receiver-side and it does not affect the amount of demand of each customer, but its actual need for service. That is, at each site, a call for service can occur with a given probability, but the amount of good to be served is not relevant. It is assumed that calls for service arise independently at the different sites. In this setting, once the facilities are located and customers are assigned to open facilities, calls for service arrive and only the customers with demand need to be served. Therefore, the actual service distances are only a subset of the distances associated with the assignments decided a priori. Now, the goal is to minimize the expected value of the maximum service distance.

We propose and analyze several mixed integer programming formulations for the general case of the PpCP. Special attention is given to the particular case where all customers have demand with the same probability, which can be solved much more efficiently.

References


Different Allocation Models for Hub Location Problems with Congestion

Sibel A. Alumur\textsuperscript{1}, Stefan Nickel\textsuperscript{2}, Brita Rohrbeck\textsuperscript{2}, Francisco Saldanha-da-Gama\textsuperscript{3}

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Keywords: hub location, single allocation, multiple allocation, congestion, service time limit

In this work we propose a modelling framework for hub location with congestion. The objective is to minimise the total costs, consisting of the setup costs for the hubs and the flow routing costs. A maximum service time is imposed for the flow routed between the origin-destination pairs. Additionally, a delay is considered when there is a high traffic density in a hub, i.e. congestion. This implicates the existence of capacity constraints, which are thus also modelled.

In many situations it makes sense to impose a single allocation pattern in which each non-hub node is allocated to a single hub. Nevertheless, especially when it comes to avoiding congestion, a multiple-allocation scheme may be more appropriate.

We discuss the above issues and propose mixed integer linear programming formulations, both for the single and for the multiple allocation approaches. These models are tested using instances from the AP data set. We compare both allocation patterns with respect to cost and time. Additionally, we consider the possibility of allowing direct shipments between non-hub nodes.
Finally, we test the influence of the imposed service time on the traffic density. We compare different time limits and include the possibility of a relaxed time restriction for some o–d-pairs.

References


Multi-period hub network design problems with modular capacities

Sibel A. Alumur,1 Stefan Nickel,2 Francisco Saldanha-da-Gama,3 and Yusuf Seçerdin4

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Keywords: hub location, single allocation, multiple allocation, Time-dependent parameters

1. Introduction

Hub location problems (HLPs) deal with location, allocation and flow routing decisions to satisfy the demand between origin-destination pairs. There are several variants of the problem that have been widely studied (Alumur and Kara [1]). The establishment of hub facilities is typically a long-term strategic decision. Accordingly, its dynamic nature is often unavoidable.

In this study, we consider HLPs in a multi-period setting. We include hub network design decisions and address both the single and multiple allocation capacitated versions of the problem considering modular hub capacities.

To the best of our knowledge, the dynamic nature of hub location has been discussed initially by Campbell [3]. More recently, Contreras et al. [4] and Gelareh [5] investigated hub location in a multi-period setting and proposed solution approaches for the different problems studied.
2. Problem Definition and Formulation

We consider a finite planning horizon divided into time periods and assume a given set of demand nodes and a forecasted demand between each pair of these demand nodes for each time period. There are costs for routing the flow, operating hubs, establishing hubs and hub links, and establishing capacity modules at hubs. The problem consists of determining for each time period: i) the location of hubs ii) the capacities of the hubs iii) the allocations of demand nodes to the located hubs iv) which hub links to operate between the hubs, and v) the routes of flow between origin-destination pairs. The objective is to minimize total costs while satisfying the demand between origin-destination pairs and the capacity restrictions of hubs for each time period. It is possible to establish a new hub and expand the capacity of an existing hub during the planning horizon.

We consider both the single and multiple allocation versions of the problem and propose a mixed-integer linear programming formulation in each case.

3. Computational Tests

The CAB data set (Beasley [2]) was considered to test the modeling frameworks developed. We conducted extensive computational analyses by using the commercial solver CPLEX. The effects of changes in the various problem parameters on the resulting hub networks are investigated and reported.

References

Location Routing on Trees *

Julian Araoz\textsuperscript{1} and Elena Fernandez\textsuperscript{1}

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Keywords: location routing, tree

Location and routing problems are among core problems in multiple application areas as logistics and telecommunications. Both areas give rise to difficult optimization problems, which have received the attention of a large number of researchers. On the other hand, it is well known that location and routing decisions are most often closely interrelated. Indeed there are a number of location applications in which the selected locations will become the depots for the routes that will serve the demand of a given set of customers. However, location problems frequently ignore the tactical or operational routing decisions and focus on the strategic location/allocation decisions. On the other hand, in routing problems it is typically assumed that the depots for the routes are set in advance, despite the big influence that the location of such depots may have in the design of efficient service routes. Therefore, because of the impact that joint location/routing decisions may have on the overall costs, a joint location/routing approach is fully justified regardless of the increase in the difficulty of the resulting problem. The interested reader is addressed to [3, 5–1] for recent overviews and surveys on the topic.

The topology of the network has been exploited to derive efficient algorithms in a number of works on location/allocation problems, particularly in the case of tree networks [2, 7, 6]. In contrast, in the case of location/routing problems (LRPs) little attention has been paid to the influence of the topology of the graph where problem is defined. This is the focus of this work, in which we will see that a number of location/routing problems can be optimally solved very efficiently when they are stated on a

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tree. In particular, we give polynomial time optimal algorithms for several location/routing problems in which demand is located both at the vertices or the edges of a given tree. These results, which can be extended to cacti, can be used as the basis for heuristics for other location/routing problems on more general graphs.

References


P-graph Framework: Computer Aided Model Generation and Solution for Supply Network Optimization Problems*

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Keywords: P-graph, network optimization, decision support, software

Making strategic decisions on setup or operation of complex networks, e.g., supply chains needs computer aid due to its high complexity. A classical approach for systematically evaluating decision alternatives is mathematical programming, e.g., LP, MILP, etc. However management problems are not given in the form of a mathematical programming problem. Even if one can construct that mathematical model, it is hard to verify if the formulation involves each of the relevant decision alternatives sufficient to find the optimal solution [1].

P-graph framework originally established by Friedler and Fan for process-network synthesis has given rise to a highly effective method for algorithmic synthesis of complex networks [2] including automated generation of the corresponding mathematical models by software [3]. The P-graph representation serves an unambiguous and clear representation of precursors and final targets of a process, preconditions and consequences of the potential activities, and the decision alternatives. The P-graph is also appropriate for both visualizing and modeling location and time dependent resources and capacities [4] [5].
The current work presents the computer aid provided by P-graph software for evaluating location alternatives for extending a supply chain. Optimal locations of production facilities are determined and paybacks are estimated due to real life parameters, e.g., local salaries, energy and transportation costs, as well as taxes and overheads in neighboring countries in the Central European Area. The proposed method and software provides the optimal as well as the $n$-best suboptimal supply networks in ranked order.

References


Covering Location Problems on Networks with Edge Demand

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Keywords: covering problems, continuous demand, edge-based demand

In the classical maximum covering location problem (MCLP) the goal is to locate a number of facilities so that the demand of covered clients is maximal. Hereby, a client counts as covered if it is within a specified distance of at least one of the facilities. In the context of networks, almost all models assume that demand only occurs at nodes and that the only allowable locations for the facilities are also nodal.

While the assumption of nodal-based demand is reasonable for some applications, for many urban applications where the number of individual customers is very large, representing each customer as a separate node on a city street-based network is not feasible. It may be more accurate to represent the demand as being continuously distributed along each edge (representing a city block). This is particularly important for the facilities where the catchment areas are small and distance-dependent. Examples include the location of bus stops, ATM machines, convenience stores, and many other contexts. In these cases, aggregating the demand to nodes may lead to large estimation errors, particularly when the distribution of demand along the edge is not uniform. Another feature many such applications have in common is that facilities may be located anywhere on the
network—not just at nodes. For example, while many bus stops are located at major intersections (nodes of the street network), others are often located along the streets.

In this presentation we consider the maximal covering problem where the demand is continuously (but not necessarily uniformly) distributed along the edges, and the facilities can be located both at nodes, as well as along the edges of the network. Note that considering non-nodal locations significantly increases the complexity of the problem even when only one new facility is to be located: while nodal locations can be enumerated, non-nodal ones represent a continuum of possibilities.

We first develop efficient algorithms for a single-facility and conditional versions of the problem (the latter involves adding a single new facility to a set of pre-existing facilities). We then used these methods to develop heuristics for multi-facility models.

We note that a “natural” approach for the multi-facility model is to discretize the model by subdividing each edge into \( k \) subedges by adding new nodes; all demand is then aggregated to the augmented node set. This set also serves as the (discrete) set of potential facility locations. A regular MCLP can be solved to optimality for the discrete model, with the resulting solution applied to the underlying continuous model.

Through an extensive set of computational experiments we compare our heuristic-based approach with the discretization approach above. We show that the latter does not perform well - not only is it computationally expensive as the discretization becomes finer, but the gap between discretized and continuous values of the objective are quite large. The heuristic-based approach achieves better results with respect to both, time and solution quality.
A Branch&Bound Methodology for Locating Multiple Facilities on Networks

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Keywords: location on networks, global optimization, MINLP

In this talk we consider the problem of locating $p$ facilities on the edges and nodes of a general network, using an optimization criterion that involves nonlinear terms of the distance from the facilities to the users. In some particular cases, e.g. median, center and cent-dian $p$-facility problems, it is possible to obtain a finite dominating set, and then it suffices to solve a combinatorial optimization problem to get an optimal solution. However, in the general case in which this does not happen, we face a Mixed Integer Nonlinear Programming (MINLP) problem, which consists of a combinatorial part (the election of the edges where the facilities will be located) and a continuous part (finding the best location for the facilities within a given set of $p$ edges).

In order to solve this MINLP problem we propose a branch&bound algorithm which makes use of specialized data structures exploiting the structure of the problem. The plausibility of this method is shown by applying it to the maximal covering location problem with continuous de-
mand and the Huff competitive location problem, both in the case of multiple facilities.
A mathematical programming model for the organization of a transfusion system in a regional context

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Keywords: location, covering, healthcare sector

This work is based on a real problem concerning the organization of a public service in the healthcare sector, namely the blood transfusion system. In Italy, such system consists of a set of facilities, named transfusion centers, where blood is collected from donors, processed to be transformed in components or products, and then distributed to hospitals for therapeutic purposes. The goal of this system is to ensure that this lifesaving resource is readily available to patients whenever and wherever it is needed; in other words, it is to produce as much blood as required by hospitals (self-sufficiency goal).

As blood can be donated only on a free and voluntary basis, i.e., individuals may choose voluntarily to do donations and no remuneration is paid for this, in order to achieve the self-sufficiency goal, transfusion centers should be able to attract a significant number of donors. To this aim, the position of such centers in the location space, in particular, their distance from potential donors, plays a crucial role in order to foster donations. On the other hand, the presence of facilities produces relevant costs due to the
need of qualified and specialized staff and of dedicated equipments. We propose a mathematical model to address the problem of the organization of a transfusion system in a regional context, based on a maximal covering problem formulation [1], in which peculiar aspects related to the characteristics of the specific application are included. The model was tested on the case of Campania Region, thanks to the collaboration with the Coordinator of the Regional Tansfusion System. The obtained results provided useful indications to support activities aimed at improving the efficiency of the current organization [2, 3].

References


Post Disaster Damage Assessment with Unmanned Aerial Vehicles

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Keywords: vehicle routing, covering tour, location routing

Natural disasters such as earthquakes threaten the life of thousands and the consequences of such disasters are often drastic. During earthquakes, immediate actions play a vital role since a considerable amount of people who die during an earthquake could have been saved if first aid had been provided immediately. Typically, the first 24 hours after an earthquake is the most critical time for rescue operations to save lives and mitigate serious injuries. Moreover, information is critical in designing a supply chain that addresses the need of the population and defining the means to meet those needs [1]. Hence, quick damage assessment is important in terms of responding effectively and immediately. However, after an earthquake, it is a high probability that the normal methods of communication will be interrupted because of the damage on the phone lines or the overload on phone companies.

In this research, usage of unmanned aerial vehicles for damage assessment is proposed. For the early phases of assessment, the vehicles should travel to the most critical nodes which consist of hospitals, schools, sanctuaries etc. It is necessary to see all of the critical nodes to do an accurate damage assessment. The coverage range of the vehicle is assumed to be a semicircle with the radius $\alpha$. Hence, the vehicle can see a node without visiting it; if the distance of the node to the tour of the vehicle is less than $\alpha$. It can be concluded that the problem is to optimize the route of the unmanned aerial vehicles such that it covers all of the critical nodes while minimizing the travel time during the first hours of the disaster.

It is possible to find similar problems in the literature. To illustrate, the vehicle routing problem (VRP) consists of designing optimal routes from
a central depot to a set of geographically scattered customers, subject to various constraints, such as vehicle capacity, route length, etc. [2] In this research, the battery life of a vehicle is considered to be a constraint for the route planning. In addition, in covering tour problem (CTP), the vertices that must be covered do not have to be visited if it lies within an acceptable distance of the vehicle route [3]. Similarly to CTP, in this research, nodes do not have to be on vehicle routes if they lie within the vehicles’ range.

Another variable considered in this research is depot location. Each vehicle should have a depot to start and end the tour. To identify the number and location of the depots, location routing problem (LRP) is considered, in which a feasible set of potential facilities are given, and the location of the facilities and the distribution routes from those facilities are determined [4].

In this research, a mathematical model is developed to optimize the routes of unmanned aerial vehicles on a network and to locate the depots of the vehicles. Since the Asian side of Istanbul, Turkey is under a high risk of an earthquake, a pilot study is conducted in this area. Data is collected from the county of Kartal which is at the first degree earthquake risk area and has a square measure of 48.000 m². Critical nodes are determined considering the possible shelter areas, hospitals, and schools. In conclusion, the route of the unmanned aerial vehicles is optimized for the Kartal area of Istanbul.

References

Solving the Absolute $p$-Center Location Problem on Large Networks

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Keywords: Absolute $p$-center location, facility location, network design

The $p$-center problem is to locate $p$ facilities on a given network $G = (N, E)$ with vertex set $N = \{1, \ldots, n\}$ and edge set $E$, so that the maximum of distances between demand points (vertices) and the facilities (centers) they are assigned to is minimized. The $p$-center problem can be classified into two categories as absolute and vertex restricted according to the placement of the facilities over the physical infrastructure that is considered as a network. In the absolute $p$-center problem the facilities can be placed on vertices (nodes) or anywhere on the edges while in the vertex restricted $p$-center problem the facilities have to be placed on the vertices of the network.

The experimental studies conducted for solving the absolute $p$-center problem in the literature are restricted to small networks. $[3]$ solves the absolute $p$-center problem on a network with 60 demand nodes and 174 edges and this is the largest network attempted in the literature.

In this paper, we aim to solve the absolute $p$-center problem on large-scale general networks. We implement the double bound algorithm proposed by $[2]$. The double bound algorithm is based on systematically solving successive restrictions of a mathematical model proposed by the authors. They use the algorithm to solve the vertex restricted $p$-center problem. It can also be applied to the absolute $p$-center problem, but requires
the construction of the finite set of potential facilities and distinct radius values. We provide new upper and lower bounds for the problem and propose a method for generation of the set of potential facilities by utilizing the proposed lower and upper bounds.

The optimal value of the vertex restricted $p$-center problem is an upper bound on the optimal value of the absolute $p$-center problem. After solving the vertex restricted $p$-center problem, we apply a one-center improvement procedure to the solution obtained and this procedure gives us a feasible solution for the absolute $p$-center problem with a possibly improved value. This new solution value becomes our improved upper bound value for the absolute $p$-center problem. Additionally, we prove that the optimal value of the absolute $p$-center problem cannot be less than half of the optimal value of the vertex restricted problem. This result provides us a new lower bound value for the absolute $p$-center problem, which is equal to the half of the optimal value of the vertex restricted problem.

We make use of several theoretical results to decrease the number of potential facilities as much as possible so that we can solve the individual mathematical models in our method as quickly as possible. We solve the absolute $p$-center problem on networks from OR-Library [1] with 900 demand nodes and 16056 edges in reasonable amount of time.

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**References**


Location of Rectangles for Graphs Visualization

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Keywords: Data Visualization, Rectangular Maps, Mixed Integer Nonlinear Programming

In this talk we address the problem of representing a set of individuals, to which there are attached weights and a binary relation, by means of a rectangular map, i.e., a subdivision of a rectangle into rectangular portions, so that each portion is associated with one individual, the areas of the portions reflect the weights, and portions adjacencies reflect adjacencies the binary relation. This rectangles location problem is formulated as a three-objective Mixed Integer Nonlinear problem. The first objective seeks to maximize the number of true adjacencies that the rectangular map is able to reproduce, the second one is to minimize the number of fake adjacencies that the rectangular map adds, and the last one is to minimize the total deviation of the areas of the portions in the rectangular map from the weights. We study the tradeoff between the objectives by solving the problem with the weighted summation of the objectives. Our numerical results, as those presented in the Figures below, demonstrate that is is possible to provide a collection of rectangular maps with different tradeoffs between an accurate representation of the weights by areas versus an accurate representation of the relation by adjacencies.

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Figure 1: Netherlands rectangular map with objectives

\[ |E \cap E_P| = 17, \ |E^c \cap E_P| = 7, \ \sum_{r=1}^{N} |\omega_r - area(P_r)| = 0.239. \]

Figure 2: Netherlands rectangular map with objectives

\[ |E \cap E_P| = 20, \ |E^c \cap E_P| = 1, \ \sum_{r=1}^{N} |\omega_r - area(P_r)| = 0.390. \]

Figure 3: Netherlands rectangular map with objectives

\[ |E \cap E_P| = 22, \ |E^c \cap E_P| = 1, \ \sum_{r=1}^{N} |\omega_r - area(P_r)| = 0.509. \]
Hedging uncertainty in the shelter site location problem

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Keywords: shelter site location, humanitarian logistics, disaster planning, stochastic optimization

Facility layout problems determine the placement of facilities in order to obtain an efficient arrangement based on some given criteria. The common criterion considered in most of facility layout problems is minimization of total material handling cost between facilities. Material handling cost plays a very important and critical role while calculating the costs of a manufacturing system. Obviously, material handling cost of a manufacturing system depends on its layout type. Therefore, in order to reduce the material handling cost, an efficient layout of facilities is necessary.

This study addresses a new meta-heuristic algorithm to solve a typical facility layout problem which considers a rectangular closed loop material handling path for locating the cells. The proposed algorithm applies a modified version of the recently invented migrating birds optimization (MBO) method. The modified MBO (MMBO) algorithm uses the neighborhood operators of genetic algorithm such as crossover and mutation.

In the computational experiments part of the study, the proposed MMBO algorithm is coded in Matlab and its efficiency is examined over some benchmark problems of the literature of facility layout problems which have different sizes varying from 4 to 30 cells. The experiments
proves that in most of the benchmark problems the results obtained from the proposed MMBO is better than those obtained by the meta-heuristics such as MBO and simulated annealing and also the exact solutions provided by Xpress solver.

References

Green Location Routing Problem

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**Keywords:** green logistics, $CO_2$ emissions, location routing problem

Green logistics covers classic logistic activities with attention to not only reducing the cost but also minimizing the environmental and social side effects of these activities. These side effects include but are not limited to waste, noise, energy usage, greenhouse gas (GHG) emissions. Recently, researchers have focused on the extension of classical logistics problems by considering environmental effects to reduce the GHG emissions on transportation sector. Since the objective of the Vehicle Routing Problem (VRP), which is one of the widely applicable OR problems in logistics, is to minimize the cost which is directly proportional to the travel distance, it also works to reduce the fuel consumption and GHG emissions considerably (Sbihi and Eglese [6]). However, minimizing the travel distance does not guarantee minimal fuel consumption or GHG emissions since neither fuel consumption nor $CO_2$ emissions depend solely on the distance traveled. The vehicle curb weight, roadway gradient, speed, congestion, fleet size and mix and payload are some of the many factors that have an effect on fuel consumption and $CO_2$ emissions (Demir et al. [3]). Estimating fuel consumption accurately requires one to look at all the factors that play a role in this area.

The concept of green routing is introduced by Kara et al. [4]. With the observation of the fact that reducing the travel cost does not always minimize the GHG emissions and fuel consumptions and that the load of the vehicle also plays a role in the minimization of aforementioned factors. Palmer [5] also has studied the integration of vehicle routing and $CO_2$ emissions in his Ph.D. Dissertation. Bektas and Laporte [1] have introduced a pollution routing problem with a more accurate fuel consumption model. Green routing has been rewarded considerable attention in the Operational Re-
search society after these studies. Different versions of this problem, such as the location routing problem (LRP), have also been studied. There are a few studies in green logistics that cover both routing and location although these studies generally consist of simpler emission models.

In order to aid this lacking area of literature we have studied green LRP with a more complex and thus more accurate emission model. To achieve this we have used the comprehensive modal emission model (CMEM) since it covers more of the vehicle based factors such as the engine friction coefficient, the vehicle engine speed and so on. (Demir et al. [2]).

To cover all real-life conditions in the proposed problem our model includes time windows for customer service and time dependent travel times due to possible congestion on the proposed routes. We have also considered speed and payload as decision variables in our model to more accurately estimate emissions.

The proposed problem is to decide on the location of depots and routes between customers while minimizing the total cost which covers the fixed cost of establishing depots, operational cost of sending flows and \( CO_2 \) emission costs. The introduction of \( CO_2 \) emission costs allows us to utilize this problem from a single objective function.

References


On location modeling in Energy Generation Capacity and Transmission Extension Planning

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Keywords: location, multistage mixed 0-1 stochastic, energy

One of the great and difficult problems that EU is facing today consists of the estimating the timing for clean power generation technologies and electricity free transmission expansion network at a pan-European level in a long term (e.g., 30 years time horizon). A stochastic multiperiod mixed integer optimization model is presented as well as some hints on the different algorithmic approaches for problem solving. This modeling will allow to determine the appropriate feasible mix of power generation sources (ranging from less thermal related sources to more renewable ones: hydroelectric, wind, solar, photovoltaic and biomass), power generation plant / farm locations and dimensions, and location and capacity of new lines in the transmission network. The solution should satisfy the electricity demand from main focal points in the European region, help to eliminate existing technological and political barriers, and maximize different types of utility criteria at pan-European level. The main parameters are uncertain, so, a set of scenarios should be generated. There is not an unique function / criterion to consider. Rather it is a multicriteria problem, since the model must consider the maximization of the Net Present Value (NPV) of expected investment and consumer stakeholders goals over the scenarios along the time horizon subject to risk reduction of the negative impact of non-wanted scenarios on multiple types of utility objectives and stake-
holders at European level. Some of those other utility objectives are the maximization of power share of cleaner, safer and efficient energy accessible to all consumption nodes, the minimization of the cost investment from private and public institutions, the maximization of generation and transmission network reliability, etc. Additionally, the maximization of the expected global profit NPV is subject to time stochastic dominance constraints for a set of profiles for each function (including the objective one). Each profile is given by the 4-tupla: threshold on the function value and maximum shortfall allowed for each scenario group at selected time periods as well as related target bounds on the probability of failure on reaching the threshold and expected shortfall, see [4]. This gigantic problem cannot be solved up to optimality such that a realistic approach consists of a combination of sample scenario schemes, inexact scenario node cluster decomposition algorithms [2, 3] for providing (hopefully, good) feasible solutions, strong lower bound providers as Lagrangean decomposition [5] to assess the goodness of the feasible solutions (and, frequently, obtaining the optimal one), and high performance computing [1, 2].

References


On the strongest Lagrangean bounds for stochastic location-assignment problems

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Keywords: Location-assignment, multistage 0-1 stochastic, Lagrangean duals

A multistage discrete facility location-customer assignment problem is considered with uncertainty in the costs and some of the requirements along a time horizon. Based on a strong pure 0-1 Deterministic Equivalent Model (DEM) presented elsewhere [1], a cluster Lagrangean Decomposition approach for obtaining strong bounds of the solution value of the problem is developed. The DEM is formulated by a mixture of the splitting representation up to a given stage, so-called break stage, in the scenario tree used for representing the parameters’ uncertainty, and the compact representation for the other stages along the time horizon. The dualization of the nonanticipativity constraints (NAC) for the variables up to the break stage results in a model that can be decomposed into a set of independent scenario cluster submodels. The number of scenario cluster submodels in such decomposition coincides with the number of scenario tree’s nodes (i.e., scenario groups) in the immediate next stage to the break one. The NAC for the variables in the cluster submodels are implicitly satisfied, see [3]. A set of schemes of Lagrange multipliers updating is considered, namely the popular subgradient method (SM) [4], the Volume Algorithm (VA) [2] and the Lagrangean Progressive Hedging Algorithm (LPHA) [6, 7]. Additionally, we use the Dynamic Constrained Cutting Plane (DCCP) scheme [5]. The aims consists of obtaining the strongest
Lagrangean bound of the original model. The same stopping criteria have been considered for the four schemes.

A broad computational experience is presented to assess the quality of the solution obtained by the new approach versus the state-of-the-art MIP solver CPLEX as well as for performing a computational comparison among the tested Lagrange multipliers updating schemes. The dimensions of the instances in the testbed are up to 15 facilities, 75 customers, 6 stages and 200 scenarios. The resulting stochastic models for the biggest instances have over 400000 constraints, 350000 (0-1) variables and 2000000 constraint matrix nonzero elements. Given those huge dimensions, plain use of CPLEX could not provide even a feasible solution before running out of memory for the biggest instances and it could not prove optimality of the solution in the allowed time limit (24h) in some others. On the other hand, the proposed approach requires a very affordable elapsed time. The different schemes frequently obtain the optimal solution for most of the instances. In some others either the CPLEX optimality of the solution is proved or a very strong bound is provided for the incumbent solution obtained by other means, in particular the FRC heuristic introduced in [1].

References


The Demand-Selective Location Routing Problem: the School Districting Application

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Keywords: school districting, location routing problem, heuristics

Problem Definition

In Turkey, eight years primary education is obligatory. [1] However, in some districts, there isn’t any school. Thus, in order to provide education services for the children living on these districts, the government runs the school districting program. In this program, the children of the districts with no school are transported, free of charge, by the governmental busses to “close” districts with appropriate schools. These schools, that other children are also transported to, are called central school. If the central school is close enough to a district, then the students are asked to walk to the school.

School districting is widely used in Turkey and in other countries, as well. From operations research perspective, the school districting problem involves the decisions of selecting the central school(s) and finding the bus routes to carry the children of the districts with no school to central schools. This problem structure is very similar to the well-known location routing problem. [2][3][4] One main difference is that in LRP, all demand points must be served where as in school districting application, depending on
the location of the central school, some districts will be visited by the bus
tour and some (the ones close enough to the central school) will not be
visited by the bus tour. There is also an extension where the students walk
to other districts, to be picked up by the bus.

We now develop mathematical models for the two basic variations of
school districting problem: Walk-to-School and Walk-to-Route and School.
Similar to the school bus routing problem, different variations of the WTS
and WTRS can be defined and modeled. We propose extensions to the
WTRS as it is more general. We first impose a “distance constraint” for each
route so that, each bus finishes its journey within a predetermined bound.
Another variation of the models proposed can be a cumulative version. As
discussed in the literature (Kara et al., 2007a, 2007b) for certain VRP ap-
plications the travel cost cumulatively increases with the amount carried.
Finally, we define the D-Cum WTRS as where the total traveled distance in
the Cum WTRS is also controlled.

In summary, we provide mathematical models and heuristic approaches
for minimizing the cost of school districting application and its variations
while covering all students and obeying all associated laws and regula-
tions regarding the process given by the government. The real-world ap-
plication is different from a vehicle routing problem because the real-world
dynamics has a tradeoff between walking to school or to bus depending
on the selection of the central school. This paper contributes to the liter-
ature by presenting the new problem of school districting and providing
an extended mathematical models for the solution. We call the proposed
problem as the demand-selective location routing problem (D-SLRP).

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Multi-directional local search for a sustainable supply chain network design model

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Keywords: Supply chain network design, bi-objective optimization , multi-directional local search, large neighborhood search

1. The problem considered

The increasing importance of environmental issues has prompted decision-makers to incorporate environmental factors into supply chain network design (SCND) models. We propose a bi-objective SCND model to minimize two conflicting objectives: the total cost and the environmental impact expressed by $CO_2$ emissions.

The logistics network consists of four layers: suppliers, plants, distribution centers (DCs) and customers. The model considers several possible transportation modes in the network, each transportation mode having a lower and upper capacity limitation. Moreover, we consider different candidate technology levels at the plants and DCs. Each technology represents a type of service with associated fixed and variable costs and $CO_2$ emissions. A higher-level technology may reduce carbon emissions, but is likely to require more investment cost.

The model considers $CO_2$ emissions caused by all industrial and logistics operations as well as transportation. The main issues to be addressed in the sustainable SCND model includes determining the number, location, and technology level at plants and DCs, suitable transportation mode, and product flows between facilities.
2. Solution method

We solve the corresponding bi-objective mixed integer linear programming model with the multi-directional local search (MDLS) framework [1]. The efficiency of this recent framework has been proved on the multi-objective knapsack, set packing and orienteering problems, but to the best of our knowledge, this is the first attempt to solve a facility location problem with it. The MDLS is based on the principle of separately using independent single-objective local searches to iteratively improve the Pareto set approximation. The motivation for using this framework is the capability of using already implemented single objective optimization components. In our case, we use a large neighborhood search algorithm [2] as single-objective method. Our algorithm can be decomposed in the three following steps:

- **Phase 1: look for an initial Pareto set approximation.** The initial phase of the single objective LNS is executed separately for each objective. The output is an initial Pareto set approximation.

- **Phase 2: Intensification around the Pareto set approximation.** The Pareto set approximation is improved by exploring the neighborhood of all the solutions in this set with a Multi-directional local search.

- **Phase 3: optimization of product flows.** After stabilizing the location and transportation mode decisions for all Pareto set approximation solutions in phase 2, we determine the optimal product flows by applying the Simplex algorithm to all solutions in the set.

3. Computational results

We assess the performance of our approach through a comparison with the well-known $\varepsilon$-constraint method. In particular, we analyze the Pareto fronts given by both solutions on a set of 60 generated instances and show that the efficiency of our approach improves when the instance size grows.

References


Planning and Scheduling Aircraft Missions by P-graphs to Eliminate Empty Legs*

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Keywords: P-graph, decision support, decision support, logistics

The actual investigation aims at providing computer aid to member nations of Strategic Airlift Capability to optimally coordinate airlift requests and utilize spare airlift capacities and capabilities from other nations. Spare capability can be part loads and even more frequently empty legs, or combinations of the two.

A flight leg is the simplest trip form a single take off to landing. Each mission is panned as a series of legs. An empty leg is a flight with no useful load, e.g., flight from the aircraft’s base to the pick-up point. From economic point of view 97% of the cost of a mission is the fuel cost, and an empty leg cost almost the same as a full load leg. Thus, minimizing the number of empty legs by more effective scheduling is crucial. However, several practical conditions complicate the scheduling. For example, the shipments are stored on aircraft specific pallets, and thus the availability of such pallets on the airbase is critical from the scheduling point of view. If necessary a flight has to be dedicated to transport empty pallets to an airbase from others. Another component is crew scheduling. A third one is taking into account flight permits. Due to all the above mentioned con-

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straints a strong theoretical basis is required to be able to provide appropriate computer aid for multi-national mission planning.

It has been shown that the P-graph approach to process-network synthesis (PNS) originally conceived for conceptual design of chemical process [1] provides appropriate tools [2] generating and analyzing structural alternatives for supply scenarios [3]. Extension of the original P-graph framework to handle time-constraints on the availability of the resources, duration of the activities, and deadlines for the final targets are incorporated into the mathematical model of PNS [4]. Time constrained PNS (TCPNS) is capable to solve classical scheduling problems and vehicle scheduling problems as well [5].

In current examinations the aircraft mission planning and scheduling is formulated as TCPNS problems. The P-graph model proposed for the solution can express all the necessary restrictions involving times of availabilities of the aircrafts, pallets, deliverables, permissions, as well as the flight hours of the crews. Finally, the P-graph solver generates the optimal and alternative suboptimal mission plans and schedules.

References


A Lagrangian Approach for the Stochastic $p$-Median Problem

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Keywords: $p$-median, lagrangian relaxation, discrete location

The $p$-median problem is one of the most known problems in Discrete Location due to its many applications (clustering, location of emergency services, political districting, etc.). It consist in, given a network of $n$ nodes and a given positive integer number $p$, choosing $p$ of these nodes (the medians) and allocating each of the other nodes to one single median each so that the total allocation cost be minimum. The problem is very hard to solve and has been widely studied in the literature in the last decades, with the best exact methods being [1] and [2], the last of which uses a so-called radius formulation.

However, in many real applications the data available are unreliable or, at least, not known with full accuracy. In this paper, we study the particular case in which the costs of the objective function for the $p$-median problem are not deterministic but uncertain and this uncertainty is modeled using scenarios. As a consequence, the model based on the radius formulation for this problem is much larger (as many times as scenarios we are considering), which makes it untractable even for a moderate number of scenarios. In order to solve this model, we will present a heuristic approach based on Lagrangian relaxation ([3]). In the proposed algorithm, an auxiliary heuristic is used at every step to obtain feasible primal solutions that allow to update the upper bound. We will show with a computational study that, by using this method, we can solve efficiently much larger instances.
References


Library of Location and Layout Algorithms (LoLoLA) and Urban Event Planning*

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Keywords: software, civil security, public events

In this talk we show the operating mode of the Library of Location and Layout Algorithms (LoLoLA) and report on some specific public security issues dealt with LoLoLA.

1. Locational Analysis and Urban Security

The Library of Location and Layout Algorithms (LoLoLA) is on the one hand a successor of the library LoLA [1] developed by the optimization research group in the University of Kaiserslautern about 15 years ago. In its function the main purpose is to provide a user-friendly software package for our location community to test research ideas or to use in teaching.

On the other hand it is a tool helping in decisions related to urban security. In particular, we deal with location and layout questions in the context of public events as part of the research consortium "Decision Support Systems for Urban Public Events: Multicriteria Integration to Achieve Openness and Security (MultikOSi²)". In this joint project of emergency plan-

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²www.multikosi.de
ners, industrial partners, and optimization-simulation specialists, the issue of achieving a balance between security, user-friendliness and economic success is tackled in a multicriteria approach.

The optimization research group of Kaiserslautern is part of this consortium and responsible for the location and layout subproject, in short StanLay (German: Standort und Layout).

2. Features of LoLoLA

LoLoLA is Python-based and, therefore, runs on most operating systems. It contains implementations of classical continuous, network and discrete location algorithms, as well as some applications like camera location, art gallery models, or public event layouts. The software will include an application programming and a graphical user interface. A simple classification scheme, introduced in [2], is used to guide the user through the interfaces. The library is able to automatically detect potential solution algorithms to solve a given problem, and after solving it, the solution can be plotted (see Figure 1). For the output of multicriteria models a spider-web for visualization is used.

References


The Discrete Parallel Machine Makespan Scheduling-Location Problem *

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Keywords: ScheLoc, discrete location, integrated problems

Scheduling-Location (ScheLoc) Problems combine the two fields of location planning and scheduling theory. The goal of ScheLoc Problems is to simultaneously locate a set of machines, transport a set of jobs to the machines and schedule the jobs such that some scheduling objective is optimized. This type of problem was introduced by Hennes [1] and so far only Single Machine ScheLoc Problems have been studied.

We consider the Discrete Parallel Machine Makespan (DPMM) ScheLoc Problem, i.e., the problem of selecting a fixed number $p$ of machine locations from a finite set of possible locations and schedule a given set of jobs on the machines such that the makespan is minimized. We propose several heuristics to solve this problem.

1. Problem Formulation

Let $\mathcal{N} = \{1, \ldots, n\}$ denote the set of jobs, $\mathcal{M} = \{1, \ldots, m\}$ the set of possible machine locations and $\text{Dist} \in \mathbb{R}^{n \times m}$ the matrix of distances, i.e., $\text{dist}(i, k)$ is the distance between the location of job $i$ and possible machine

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location \( k \). Furthermore, let \( p_i \) be the processing time of job \( i \) and \( p \) the number of machines to be located. A job \( i \) cannot start processing on a machine in location \( k \) before it arrives there. This point in time denotes the release date of job \( i \) in location \( k \) and is given by the distance between the corresponding locations, i.e., \( r_{ik} = \text{dist}(i, k) \).

The DPMM problem is the problem of selecting from \( \mathcal{M} \) exactly \( p \) locations and schedule all jobs \( i \in \mathcal{N} \) on the selected machines such that the release dates \( r_{ik} \) are respected and \( C_{\text{max}} = \max\{C_i|i \in \mathcal{N}\} \) with \( C_i \) the completion time of job \( i \) is minimized.

2. Clustering Heuristics

The DPMM ScheLoc Problem consists of three different problems: Locating the machines, assigning the jobs to the machines, and scheduling the assigned jobs on each machine. Once the first two subproblems are solved, the scheduling part reduces to \( p \) single machine problems which can be solved optimally. To solve the first two subproblems we consider clustering heuristics, i.e., heuristics that split the jobs into clusters and find a location for each of the clusters called cluster center. For pure location problems the assignment into clusters is done considering the distance between the locations. Since in the ScheLoc Problem the quality of the solution is also dependent on the resulting schedule, we identified several clustering criteria that take this data into consideration, like balancing the total processing time of clusters. We tested those criteria with three different strategies:

1. First choose all cluster centers then assign the jobs to the cluster centers.
2. First cluster jobs then assign them to a cluster center.
3. Iteratively choose a cluster center and assign jobs to it until \( p \) clusters are obtained.

To improve the obtained solutions we developed a local search algorithm that iteratively improves the cluster centers and the clusters until a local optimum is reached. Tests show that this algorithm runs fast even for large scale problems and is able to improve the starting solution in many cases.

References

Extended Sink Location Problems *

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Keywords: network location, sink location, network flows

The choice of appropriate sinks which provide enough capacity to discharge a given supply inside a network is a common problem in many applications, for example the choice of shelter locations during an evacuation. We extend the existing sink location models of [1, 2] and provide theoretic as well as practical results for the new models.

1. Classification Scheme

In the sink location problem (SLOC problem) we are given an undirected network $G = (V, E)$ with vertex set $V$ and edge set $E$. Each vertex $v \in V$ has a supply value $a_v$, a capacity value $k_v$, and a cost value $c_v$. Each edge $e \in E$ has a capacity value $u_e$. Our aim is to find a subset $W \subseteq V$ of vertices, called sink cover, such that the supply of all nodes can be discharged to these sinks. The flow induced by the sink cover $W$ may have to respect the edge capacities as well as the node capacities of the sinks, while minimizing the total cost $c(W) = \sum_{v \in W} c_v$ for the chosen sinks. Sink location problems can be categorized depending on the underlying sink cover type:

**single/plural** If the flow from one node may only be sent to a single other node, the problem is called a single SLOC problem. Otherwise, it is called a plural SLOC problem.

**simultaneous/non-simultaneous** If the flows originating at different vertices are considered at the same time, i.e. the flow values add up on

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the edges, then the problem is called a simultaneous SLOC problem. Otherwise it is called a non-simultaneous SLOC problem.

**additive/independent** Similarly, if the flows reaching a sink add up, the problem is called an additive SLOC problem. If the flows do not add up at the sinks then it is called an independent SLOC problem.

In total this gives eight configurations for SLOC problems. To shorten the notation we introduce the following three position classification scheme: In the first position we write 1 for single and \( n \) for plural SLOC problems, in the second position we write \( \max \) for non-simultaneous and \( \sum \) for simultaneous SLOC problems, and in the third position we write \( \max \) for independent and \( \sum \) for additive SLOC problems. Using this scheme we would write \( n|\max|\sum \) for a plural, non-simultaneous, additive SLOC problem.

2. **Results**

A few of these configurations have been considered before in the context of source location. The existing results from source location have been transferred to the sink location context [1–3]. Unfortunately, only configurations that consider edge and sink capacities in the same fashion, i.e., only problems of type \( \bullet|\max|\max \) and \( \bullet|\sum|\sum \), can be reduced to already known source location problems.

We give new complexity results for those configurations that do not consider edge and sink capacities in the same way. These problems are NP-hard in general and solving them requires the use of large networks or multi-commodity network flows. In addition to theoretic results we also provide fast solution methods for some configurations and demonstrate the practical efficiency by numerical tests on randomly generated graphs and graphs arising in evacuation problems.

**References**


Optimal View Points for Fireworks Displays with Respect to Solid Angles

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Keywords: fireworks displays, solid angles, optimal view points

Fireworks displays are typical features of summer in Japan. In this study, we propose a mathematical model to evaluate the optimal view points for fireworks displays. We calculate the solid angles of actual fireworks displays with respect to the shielding by millions of existing buildings in Tokyo metropolitan area.

1. Background and Purpose

Fireworks displays are typical features of summer in Japan. Lots of Fireworks festivals are held in everywhere, and people enjoy the art in the air. However, in metropolitan area, there are so many buildings that fireworks are often shielded by them. Searching the optimal view points which acquire the full visibility is quite important.

In this study, we propose a mathematical model to evaluate the optimal view points for fireworks displays. Using the scanning line vector methods, we calculate the solid angles [1] of actual fireworks displays with respect to the shielding by millions of existing buildings in Tokyo metropolitan area (Figure 1 and 2).
Figure 1: Visibility map from Streets

Figure 2: Visibility map from Buildings

References

Exact Models for Open Field Layout Problem with $l_2$ and $l_1$ Distances

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Keywords: layout problem, open field, modeling

In a layout problem of manufacturing cells, cells have rectangular shapes and must be positioned without overlapping. The objective is to minimize the total transportation among the objects. The transportation quantity depends on the ow among the objects and their distances.

A general restriction is that the rectangles must have vertical and horizontal edges and can be rotated by 90, 180, and 270 degrees. Each cell has a pick-up point which is the middle point of a fixed edge. Transportation is carried out between the pick-up points.

There are models describing the constraints of the problem including the non-overlapping properties of the cells, however the distances are approximated only. This paper provides the first models when the distances are exact distances.

The meaning of the word "exact" is that the distance of two points is exactly the length that the vehicle passes if it goes from one point to the other. If the distances are measured by Euclidean distance ($l_2$ distance), then the distance of the points in the layout is their Euclidean distance if and only if there is no obstacle between the two points, i.e. it is possible "to see" the other point from one of the points. If the distances are measured by Manhattan distance ($l_1$ distance) then the distance of two points in the layout is their Manhattan distance if and only if there is a sequence of adjacent vertical and horizontal intervals such that this sequence goes from one point to the other and always goes both vertically and horizontally in the
same direction, for example it always goes up (vertical motion) and right (horizontal motion).

An exact model of the layout of the rectangular cells must satisfy the following constraints: the cells must not overlap, the cells can be rotated by 90, 180 or 270 degrees.

The model uses the coordinates of the central points of the rectangles as variables. The coordinates of the pick-up points are also important as the transportation is carried out among them.

In our first nem model we calculate the distance of two points (vertex or pick-up point) of two cells based on the above mentioned coordinates. The distance of the two points is the Euclidean distance if and only if there is a feasible segment between the two points, i.e. there are no cells between the points. Otherwise the distance will be increased by $M$.

The final main step is the formulation of the objective function. It is the minimization of the sum of the flow between cells weighted by the distance of the pick-up points of the cells, where the edges of the graph are the edge points and the pick-up points.

In the second model, the positions of the cells are similar, but distances are measured by vertical and horizontal moves. The are turning points where the vehicle may turn +90 or -90 degree. The coordinates of all turning points are chosen from the coordinates of vertices and pick-up points. The vertices of the graph of minimal cost flow are the turning points.
Stackelberg location problems on networks with operational costs

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Keywords: global optimization, bi-level optimization, location on networks, branch & bound, Stackelberg problem

In a Stackelberg location problem two firms compete for market share, they both aim to locate one or more facilities trying to maximize their profit. The leader is the firm that locates first, the follower locates with full knowledge of the leader’s location. This leads to a bi-level optimization problem, where the leader has to take into account the possible locations of the follower when calculating its objective function, so that it is optimal after the follower locates its facilities.

We consider the problem on networks, where the demand is inelastic and concentrated in the vertices of the network. The competition is static and the customer’s choice is probabilistic. The facilities can be located on the edges of the network and both firms aim to locate only one new facility. The objective function is the profit obtained by the chain, which is the market share captured by it minus its operational costs. We incorporate the qualities of the facilities into the model, assuming that the quality of the players’ new facilities are discrete variables.

We tackle the problem using a Branch and Bound method, with interval arithmetic, slope arithmetic and DC bounds for the leader. A similar method with similar bounds is used to refine the follower’s choice. In the talk computational results for small and medium sized networks will be presented.
References


Heuristic Approach for Solving a Dynamic and Stochastic Location-Routing Problem

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Keywords: location routing, dynamic, stochastic, heuristics

Within locational analysis, problems taking into account distribution aspects are named location-routing problems (LRP). This integrated approach has been studied with increase depth [1, 2, 4]. In the literature, LRPs are usually addressed using deterministic and static settings [2]. However, for coping with variability and uncertainty in data (concerning demand, costs, etc.), these approaches often fail to provide robust solutions, raising doubts on its applicability to real-world scenarios.

Although dynamic and stochastic LRPs are repeatedly suggested as interesting research avenues [1–3] very few works have addressed these aspects, although clearly fitting many decision-making scenarios.

We present a heuristic approach for solving a dynamic and stochastic capacitated LRP. For each time period several scenarios are generated, where a random subset of clients has a demand realization (it is assumed that the demand of each client, when existing, follows a log-normal distribution). For each scenario (in itself a capacitated LRP) a hybrid genetic algorithm is used to solve it. The solutions obtained from each scenario are then analyzed regarding its cost and robustness, from which one is chosen/constructed for that time period; different criteria for obtaining this solution will be addressed. The depot configuration of the chosen solution is used in the following time period. Considering all time periods, the overall best solution is sought: the one presenting the least cost while achieving
specified service levels. Results will be presented and discussed, emphasizing the main differences between the proposed approach and deterministic and static approaches.

References


The Maximum Trip Covering Conditional Location Problem on Tree Networks

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Keywords: location, networks, covering problem, mixed distances

A rapid transportation system can be represented by a network embedded in the plane. However, demand is usually represented by points in the plane not necessarily belonging to the network. Several location problems with coverage objectives in a planar-network context have been considered in the literature (see a review in [1], and references therein). On the other hand, a new mixed planar-network covering model has been studied in the recent papers [2, 3], in which the aim is to cover origin-destination pairs instead of single points.

This paper deals with an origin-destination covering conditional location problem in a mixed planar-network space. We consider a set of existing facilities in the plane and assume that nodes of a railway tree network embedded in the plane are either junctions or stations already located, such that traveling along the network is faster than traveling within the plane with some planar metric. Each node to node travel time includes a constant dwell time at each intermediate station, and excludes dwell times at the terminal nodes. The demand is codified by means of a matrix in which each element is the number of trips associated to each O/D ordered pair obtained from the points located in the plane.

With this assumption, an O/D pair is covered if the mixed travel distance between the origin and destination by using the network is not higher than a given acceptance level related to the travel time distance along just the plane. Taking into account that the stations already located cover the trips of a set of O/D pairs, the conditional location problem con-
sists in locating a new station in the network so that the number of trips corresponding to the resulting covered O/D pairs is maximized.

A new station located in the network leads to a double effect: the first one is related to the network accessibility, with a possible increasing of the amount of O/D pairs captured. The second effect deals with the O/D pairs already covered, since the dwell time at the new station could increase the mixed travel distance of these pairs, and it is possible that some of them would be lost for covering purposes. That is, they are opposing effects since simultaneously the objective function value increases with the captured new O/D pairs and decreases with the O/D pairs which are lost.

Both effects are incorporated into the method used for solving the problem. Likewise, the solution approach is based on decomposing the problem into a collection of subproblems such that, for each of them, a subquadratic in the number of demand pairs Finite Dominating Set is deduced.

References


p-Cable Trench Problem with Covering

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Keywords: location, network design, covering, heuristics

We introduce the p-Cable Trench problem with Covering. In this problem, p primary servers (e.g., routers) are located and a set of secondary servers (e.g., extended range WiFi antennas) is connected to each of them, to achieve complete demand coverage by a service (e.g., WiFi), at minimum cost. The topology is a forest, in which the primary servers are roots of trees whose leaves and some other nodes are occupied by secondary servers. Some of the nodes of the trees are Steiner nodes. Both primary and secondary servers provide the service within a coverage radius. The cost is composed by a trench digging cost and a cable cost. Each secondary server requires a single, dedicated cable connecting it to a primary server, and all cables must lie in a trench.

The p-cable trench problem with covering is a generalization of several known problems:

- If the coverage radius is zero and the location of primary and secondary servers is known, the problem becomes the Fixed Charge Network Design Problem.
- If the coverage radius and construction cost are equal to zero and the location of the secondary servers (antennae) is known, the problem becomes the p-median problem.
- If $p = 1$, the location of the antennae is known and the coverage radius is equal to zero, the problem becomes the cable trench problem.

- If the coverage radius is zero and location of the antennae is known, it becomes the $p$-cable trench problem.

- If $p = 1$ and the cost of distance is zero, it becomes the covering tree problem.

We propose a linear integer optimization model based on multicommodity flow, which we solve using two different Lagrangian relaxations, and a heuristic based on a modified set covering. We solve instances of up to 200 nodes, and also an application for locating WiFi antennas in Viña del Mar, Chile.
Discrete Optimization in Map Labeling: An overview and foresight*

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Keywords: discrete location, map labeling

A set $I = \{1, \ldots, n\}$ of given points in the plane are given. Associated with each point there are several possible locations $K = \{1, \ldots, k_i\}$ for a label which contains information about the point (whose shape and size are known). One of the possible locations can be “no location”. Each combination point $i$-location $k$ has a cost $c_{ik}$. Some pairs of point-location combinations are incompatible (generally because the labels overlap). How to choose the locations in order to get a nice map?

![Figure 1: Example of labeling without overlapping](image)

In Figure 1 four points to be labeled, each with four potential rectangular labels, are shown. The solution depicted can be considered good, since the labels do not overlap. Sometimes, not all the points can be labeled without

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overlapping. Since Zoraster [6] gave the first Integer Programming formulation

$$\begin{align*}
\text{min } & \sum_{i \in I} \sum_{k \in K_i} c_{ik} x_{ik} \\
\text{s.t. } & \sum_{k \in K_i} x_{ik} = 1 \quad \forall i \in I \\
& x_{ik} + x_{i'k'} \leq 1 \quad \text{if } (i, k) \text{ and } (i', k') \text{ are incompatible} \\
& x_{ik} \in \{0, 1\} \quad \forall i \in I, k \in K_i
\end{align*}$$

for locating the labels with the minimum total cost, several authors have designed different formulations to deal with different models (see, e.g., [1]-[4]).

In the talk we will analyse these models and formulations, and propose a new model and corresponding Integer Programming formulation for locating labels in a map.

References


Social Network Influence on Demand and its Impact on Forecast Accuracy

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Keywords: social network, small world network, forecast accuracy

1. Introduction

In 2014 an article presented by the SCM World’s Chief Supply Chain Officer Report 2014 [4, p. 10], pointed that “customer demand volatility” was one of the major concerns among supply chain managers worldwide. They suggested that officers should use social media more fittingly to help with demand forecasting. However, although social media information make it easier for managers to learn more about preferences at the individual level, it also creates a chain of social influence which contributes both to “inequality” and “unpredictability” of future sales [5, 1]. In this work we attempt to model the social influence using small world networks approach to capture the way information spreads.

Several studies have investigated the effects of social influence on product adoption. Earlier investigations focused on behavioral mechanisms of social influence (e.g. [3]), and latter work investigated what network topologies facilitated social influence on consumer choice (e.g. [2]). Those works have expanded our understanding about social networks and consumption, which includes the fact that social influence increases demand
uncertainty and market concentration [5, 1]. Our work proposes a model to describe demand including the effects of social influence. The model considers three factors of customer’s choice including intrinsic preference, inner-circle influence, and current product or service market share. Whereas the first factor is customer’s innate, the second and third are factors of social influence. To the best of our knowledge, this approach has been used only once before, and with limitations, by Hu et al. [1], who did consider the impact of buyer’s inner-circle. An important insight obtained by our investigation is related to defining a probability distribution that can represent well demand after social influence is taken into consideration. We bring an approximation to the coefficient of variation for any combination of parameters and we have tested the approximation on large networks (e.g., 10,000 nodes) and with very large networks. In this last case, we tested several 100,000-node networks with the STORM network at the University of Calgary, with more than 5,000 hours of dual processors core utilized for checking our findings.

This work provides three main contributions. We present the first model that considers three different factors of choice (individual preference, inner-circle influence and market share) in demand forecast. We shed light on the effect of social network on the distribution of demand. Finally, we provide a framework where further advancements can be brought up by the field of Facility Location through an approximated estimate for the coefficient of variation of demand in the presence of social influence.

References


Robust Hub Location Under Polyhedral Demand Uncertainty

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Keywords: hub location, uncertainty, robustness

Hub structure is frequently employed by transportation and telecommunication networks which aim to benefit from economies of scale. In the hub networks, the flow commodities between origin destination pairs are routed through hubs instead of direct connections between nodes. The flows are concentrated on hub nodes, hence economies of scale on transportation costs is achieved. One of the most studied problem in the hub location literature is the multiple allocation $p$-hub median problem (MA$p$HMP). This problem aims to locate $p$ hubs in a given network so that the total transportation cost is minimized as well as each pairwise demand is satisfied. Each demand point could be served by multiple hub nodes. Generally the hub network is assumed to be complete and direct shipments between non-hub nodes are not allowed. Capacitated variants of the problem enforcing limits on the flow on edges or nodes are also present.

An important factor to be considered while designing a hub network is the data uncertainty. Hub location decisions are made in the strategic planning period, usually before the system starts operating, and the implementation often takes a long time. The demand may have a large variation due to the seasons, holidays, prices, level of economic activities, population, service time and quality and the price and quality of the services provided by the competitors. Hence the demand information available in the planning phase may become obsolete in the time of operation.
Even though the hub location is a widely studied area, the literature on the hub location problems addressing data uncertainty is rather limited. To the best of our knowledge, there are only six papers dealing with the data uncertainty in the hub location context (see [1]-[6]). In these studies, either the pairwise demand values or the transportation costs are considered as the sources of uncertainty. The uncertain parameters are mostly assumed to follow a known distribution. Apart from a known distribution, the uncertainty is represented with a set of scenarios in [1] and with an ellipsoidal set in [4].

In this study, we consider the uncapacitated MAPHMP under polyhedral demand uncertainty. We model the demand uncertainty in two different ways. In the hose model, it is assumed that the only information available is the upper limit on the total flow emanating from and destined to each node while the hybrid model additionally imposes intervals on which each pairwise demand can take value. We introduce robust uncapacitated multiple allocation $p$-hub median problem under hose and hybrid demand uncertainty and propose linear mixed integer programming formulations. In order to solve large-scale problems, we devise two Benders decomposition based exact solution algorithms. Computational tests are performed on instances of the Civil Aeronautics Board (CAB) data set with 25 nodes, Turkish (TR) data set with 81 nodes and the Australian Post (AP) data set with up to 150 nodes. We analyze the cost of the demand uncertainty and compare different solution methods in terms of solution times.

References


Locating Multi-Hydrants in Water Irrigation Networks by using Expected Distances

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Keywords: water distribution systems, expected distances, location problem

Currently, the 70% of the freshwater withdrawals in the world are used for irrigated agriculture (FAO, 2011). Along the recent past decades, water pressurized distribution systems have been developed with considerable advantages in comparison with traditional open canals, since those ones guarantee better services to the users and higher distribution efficiency (Khadra et al., 2013).

Such new pressurized networks require an increase of energy consumption for their operation, according to the on-farm irrigation systems, the topography and the hydraulic configuration of the network. This can imply a significant increment of costs for farmers. In order to reduce this expense, farmers are organized into small groups to share the costs of installation and maintenance of multi-hydrants (Carrillo-Cobo et al., 2011).

The design and dimensioning of the network of pressurized water for irrigation has the following phases: Location of multi-hydrants, Network Designing, Determination of circulating flows for each of the lines and Determination of pipe diameters. Despite its importance, only very few methodologies within the scientific literature have been developed for solving the problem of how to distribute multi-hydrants in pressurized irrigation network design (García-Prats and González-Villa, 2011). The decision is double: where to put the hydrants (location), and which subsets of demand (irrigated plots) should be served by each hydrant (allocation).

The p-Median Problem (Hakimi, 1965; Daskin, 1995; Hansen and Mladenovic, 1997) is a common location-allocation model for finding p facility locations among a set of candidates so that the total access distance, required to serve a fixed demand, is minimized. In the present work, the p-median
model has been used to optimize the location of a number of service centers (hydrants) that must be assigned to demanding items (plots of the irrigable zone to be supplied) such that total travel cost is minimized. Different types of distance between points and zones (Carrizosa et al., 1998; Laporte et al., 2002) are analyzed in this contribution, in order to better fit the reality of building cost. In particular, a p-median location - allocation model is introduced by using discrete versions of expected distances (Vaughan, 1984; Stone, 1991; Koshizuka and Kurita, 1991).

References

Planning health services in primary care:  
A stochastic location allocation model

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Keywords: OR in health services, uncertainty modelling, public facility planning

In this paper we present a location allocation model to provide options for configuring the system of primary health care focusing on the location of health services and the allocation of residents among a predetermined number of health centers (HCs).

Changing the range of services providing in health care facilities can be a valuable tool for setting priorities and reorganizing the health system. Thus, we consider different configurations of the system regarding the spectrum of services for any given HC and the degree of clinical specialization, by relocating primary healthcare services close to the patient and at the same time taking into account cost issues.

Nevertheless, the provision of health care services takes place in an organizationally complex environment, making it difficult to formulate precise behavioral models. Regarding the real-world variability, uncertainty and complexity, a stochastic modeling approach is inevitable in healthcare location problems [1].

Our aim is to develop a modeling framework that comprises the uncertainty aspects of patient flows in the location of health services. We consider a discrete type of uncertainty where uncertainty is represented by a finite set of scenarios. We then introduce a stochastic location-allocation model that captures the uncertainty associated with the patient choice in service selection.
The stochastic facility location model is formulated as a two stage problem [1,2]. The first stage problem determines the location decisions and the second-stage defines the allocation decisions that are scenario dependent to contain the uncertainty factors. The main idea of this approach is that: since we cannot anticipate the future, we look for the location decisions that are expected to perform well across all allocation scenarios. We present a case study for reorganizing the network of 33 HCs operating in South Greece. By performing computational analysis, we analyze the changes in the solutions considering the following three different approaches to resolve the uncertainty by: 1) minimizing the average expected cost over all scenarios; 2) minimizing the worst-case performance; and 3) minimizing the maximum regret.

References


A Statistical Model Analysis of Urban Ambulance System and its Application to Location Problems

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Keywords: ambulance location, cooperative cover, coverage probability

This study explores ambulances’ moving data in Tokyo and attempts to model several features of them. The focus is on finding a stochastic relation between traveling distance and time of ambulances, and pairwise correlation of their busy time. Our model plays an important role to implement a cooperative cover location problem for ambulance stations, in which it works for computing a coverage probability of demand points. Throughout the study, we make use of actual ambulance moving data in Tokyo to calculate several statistics and compute the optimal solution, which is compared with the current location. The result could show how our approach works for a realistic situation.

First part of our work investigates a conditional distribution of ambulance’s traveling time given the traveling distance. Both nonparametric and parametric methods are devised and checked with each other for fitness and robustness to the data. A simple nonparametric estimation is made by constructing an empirical distribution of traveling time for each stratified distance, then a parametric model is proposed by involving a physical consideration on the relation between traveling distance and time. They are used to convert a traveling distance to demand point into the probability that an ambulance can arrive at the point within a specified time limit, which is exactly the coverage probability in covering location problems. Further analysis is made on the correlation between ambulance actions.

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We compute for every pair of ambulances the time length in which both are idle or busy in a year. The result would help us to have finer estimation of coverage probability.

In the second part we show a practical implementation of cooperative covering for ambulance location problem. Introducing a conditional probability of traveling time leads us to much simplified calculation of coverage probability by several ambulances, when they are thought of independently working. Although it is more difficult to cope with a dependent model, as is suggested by the data analysis, we propose an idea on how to take account of the interaction among ambulances with help of the result from correlation analysis.
Preventive Health Care Facility Location Planning with Quality-Conscious Clients

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Keywords: facility location, multinomial logit model, random utility, preventive health care, appointment waiting time, quality of care

In [9] and [4] probabilistic-choice models for locating preventive health care facilities are proposed. The objective of both models is the maximization of the participation in a preventive health care program for early detection of breast cancer in women, i.e. the yearly expected number of women who access a medical checkup at a mammography center. In contrast with sick people who need urgent medical attention, the clients of preventive health care choose whether to take part in a preventive health care program. That is, clients choose to patronize a certain facility location or not to take part in the program. Customer (here client) choice behavior is usually modeled by random utility models - mostly the multinomial logit model (see, [6], [1], and [3], for example). In [9] and [4] it is assumed that waiting time (for an appointment) and the quality of care (represented by a so-called minimum workload requirement) do not influence the choice behavior of the clients. Therefore, the decision is only about the locations of the facilities and the number of servers per facility. However, [4] have shown that this assumption yields suboptimal results in terms of participation.

In this contribution we relax this assumption, i.e. we consider clients’ utility function to include variables denoting the waiting time for an appointment and the minimum workload requirement (as a proxy of the quality of care). At a first glance, this would yield a mixed-integer, non-
linear model formulation as shown in [5]. We assume that the waiting time for an appointment can be considered to be categorical, i.e. the variable takes only a few discrete values. Note that this is a very common way how waiting time is modeled in empirical choice studies. As a consequence, in many case studies and applications, waiting time enters the clients’ utility function as a categorical variable (see, [2] and [8]). The minimum workload requirement is considered as a categorical variable as well, i.e. this variable indicates whether a facility satisfies the requirement. These assumptions allow us to employ the approach of [7] to arrive at a mixed-integer, linear program. Based on artificial data we show that the problem can be (optimally) solved in reasonable time using GAMS/CPLEX. Further, we apply our approach to the location of breast screening centers in Sydney, Australia.

References


An Efficient Heuristic Algorithm for the Alternative-Fuel Station Location Problem

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**Keywords:** alternative-fuel vehicle, fuel station location, heuristic, parallel computing

The problem of alternative-fuel station location is a recent, but very applicable research topic within location science. In essence, what makes the problem of determining locations of alternative-fuel refuelling stations different from those of petrol stations is the scarcity of current infrastructure. The alternative-fuel industry is suffering from a vicious circle: there is little appetite for infrastructure investment as there are not a sufficient number of alternative-fuel vehicles, the automotive industry can only produce these vehicles at high process as there are not sufficient economies of scales due to limited demand, and customers are discouraged from buying such vehicles due to both their price and the limited refuelling infrastructure. This topic is especially timely in the light of a recent European directive requiring Member States to provide a minimum coverage of refuelling points for alternative fuels. The directive provides a regulatory framework for alternative fuels such as hydrogen, electricity, liquefied natural gas and compressed natural gas. The targets are very ambitious but the current infrastructure is very limited. Thus, this is the right time for Operational Researchers to devote their energies to finding optimal or near-optimal locations for alternative-fuel refuelling facilities.

The flow-refuelling location model (FRLM) has its origins in the flow-capturing location model (FCLM). In turn, the FCLM is based on the observation that, unlike traditional location models, where facilities are to be sited near customer locations, in some cases it makes more sense to locate facilities near routes that customers already take. An important aspect of
the FCLM is that any flow (origin-destination pair) is captured by a single facility. This is sensible as one would not, for example, stop at every roadside supermarket on the way home. It is often assumed that in order to capture a flow, a facility must lie on the origin-destination path. However, it may also be reasonable to assume, especially if the network of facilities is very sparse, that drivers would make some reasonable detours to visit a facility.

The main difference of the FRLM from the FCLM is that a single facility may be unable to capture an entire flow. This is due to the issue of “limited range”, namely, that a vehicle may not be able to undertake a given origin-destination journey with a single refuelling stop. This model is most applicable to vehicles powered by alternative fuels, such as hydrogen or electricity. On one hand, such vehicles normally can cover a shorter distance on a full tank than traditional petrol-guzzling vehicles. On the other hand, the availability of alternative fuel refuelling stations is very limited.

In our paper we propose an efficient heuristic for the FRLM. It is built on the idea of using the optimal solution obtained by relaxing the integrality constraints of the mixed-integer linear programming (MILP) problems to generate a set of initial solutions for metaheuristic algorithms. However, such metaheuristic algorithms only used the information of the optimal solution in the first iteration, but did not use to support search process in next iterations. Recently, the idea of using the information of the optimal solution to support search process further (i.e., to establish a set of promising candidate variables) has been developed, known as Kernel Search. The algorithm identifies subsets of decision variables for the MILP problem by solving the relaxation problem and then solves the restricted problems to optimality by commercial MILP solvers. It has been successfully applied for several optimisation problems, including a variety of location problems. Our heuristic is somewhat different from Kernel Search but is also based on the concept of restricted subproblems. We also use a parallel computing strategy to simultaneously solve a number of restricted problems with less computation effort for large-sized instances.

We have carried out computational experiments on well-known benchmarks datasets. Experimental results show that the proposed algorithm can obtain the optimal solutions within a reasonable computation time (compared with CPLEX solver), and outperforms the other heuristics from the literature with respect to solution quality as well as computation time.
The Multi Shift Coverage Facility Location Problem

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Keywords: Evolutionary algorithms, Personnel management, Scheduling

In this paper we consider a facility location problem with manpower, multi-shift, and time constraints. It is an extension of a manpower shift planning problem discussed in Nearchou et al (2015). We will refer from herein to this problem as the multi-shift coverage facility location (MSCFL) problem. In this problem a flexible workforce, employed to work on a basis of workday shifts, provides service to a set of facilities that should serve demand over a specified planning horizon of several days. MSCFL seeks the time period (day and shift) in which each facility should be opened, as well as, the manpower to be allocated to each shift so as to complete the service targets of all the facilities within the specified time horizon at minimum cost (total opening cost plus manpower cost). We consider a capacitated setting in which each facility can be opened and closed a certain number of times. See Torres-Soto and Üster (2011) for a discussion of dynamic demand capacitated location problems.

We formulate the MSCFL problem as an integer linear program (ILP) and then present a genetic algorithm (GA) for its solution. In addition to the main characteristics of a standard GA, as described in Michalewicz and Fogel (2004), the developed GA incorporates a problem-specific coding of the MSCFL solution structure together with new special merging rules for creating offspring that exploit the structure of the problem. We test the performance of the GA by comparing its results to the results given by CPLEX for a variety of operating environments ranging from 8 to 50 facilities. The results demonstrate very satisfactory performance for the developed GA in terms of both solution time and quality. In some test instances GA out-
performs CPLEX finding solutions with lower cost over the specified time limit.

References


Locating Park + Ride Nodes in an Agglomeration: Issues, Methodologies, Criteria

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Keywords: Park + Ride, public transport, agglomeration, hypergraph, transversal, genetic algorithms, multiple objectives

1. The Outline

When locating Park+Ride nodes in an agglomeration, a limited number of nodes ought to be selected, satisfying definite criteria related to traffic, costs, environment, etc., meant for the transport mode shift (car-public transport, usually). The problem and the issues related to data, potential criteria, pragmatic questions, and an illustration for Warsaw agglomeration, are given. Then, a two-stage approach is presented, and respective methodologies (finding hypergraph transversal and specialized genetic algorithms). Some preliminary results are discussed against the background of the criteria that (may) guide the determination of solutions.

2. The Approach and the Methodologies

The approach consists of two stages: the preliminary selection of candidate nodes from the initial data (e.g.: more than 10 000 physical and 4 000 “inte-
grated” stops for Warsaw); and then, based on more precise data, relative to criteria, the choice of a subset, being the proper solution, from the candidate set. The division into two stages results from: (i) multiplicity and uncertain character of the criteria applicable; (ii) limited capacity of finding the optimum solution. In the first stage, authors’ algorithms find various transversals of the hypergraph, formed by the transport lines. Here, the hypergraph, based on the graph of public transport, is such that the hyperedges correspond to public transport lines. Finding the transversal secures that the P+R candidates cover all the lines. In parallel, a flexible authors’ genetic algorithm is used, based on an explicit transport-oriented criterion. As of now, in the second stage, where the final solution proposal is generated, only the specialized genetic algorithm is used.

3. The Criteria and the Results

The criteria applicable range from very pragmatic, even if not easily specified (individual travel cost & time), to utterly “soft” (e.g. equality considerations), so that only proxies are used. In the first stage very rough assumptions are made as to the properties of the candidate nodes, and a variety of potential solutions is secured. In the second stage, (a) the timing of transit and its cost are the precondition for the P+R system effectiveness; (b) this is coupled with the same, but in the perspective of congestion and pollution. In case (a) the weights of the objective function components, reflecting their importance, can be calibrated with the performance of the system to date or the (assumed) behavior of transport users, subjectivity being possibly avoided. In case (b) the weights are more a political, and thus more subjective matter, especially as this also has a bearing on the shape of agglomeration (urban sprawl vs. concentration). These issues are illustrated with exemplary results for Warsaw agglomeration.
Network design of electricity transmission systems with renewable energy sources

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Keywords: renewable energy, electricity transmission, network design

Energy is crucial for quality of life and energy consumption increases continuously due to high usage rates per person, population increments and technology improvements. Since nonrenewable sources are limited and scarce, meeting the demand in a sustainable manner with only these sources will not be realistic in the future. Moreover, fossil fuels contain high percentage of carbon and the use of fossil fuels leads to significant effect on the global warming through the greenhouses gases. Therefore, to decrease these effects, integrating RES for meeting energy consumption are garnered much interest. Since RES are one of the main type of sources for generating electricity, we consider the electrical power in this research.

The electricity chain from generation to consumption is usually categorized into four: generation and conversion, transmission, distribution and consumption. In generation phase, the aim of suppliers is to provide sufficient and high quality electricity. However, due to nature of RES, sufficiency turns out as main challenges and meeting especially peak demand is one of the main problems of the suppliers. In transmission and distribution, supplying continuity of electricity is an important criterion and in order to sustain the continuity of the electrical power, the reliability of the system should be considered. So, there should be alternative path(s) or components (i.e. substation) available so that in an emergency case, the electricity should be transmitted via the alternative components without damaging the overall system.

In the literature, there are many studies that conduct with the feasibility analysis of the system with RES and they use different performance mea-
sures like cost or environmental effect. There are also studies which include transmission system constraints. Ostergaard [3] analyzes transmission network in Denmark and compares two solutions: a 2020 situation with only few large plants and a 2020 situation with scattered RES. A similar analysis is also conducted for Switzerland in the paper [4] with more detailed analysis of transmission system including also substations. The authors assess grid network and decide the optimal power flow in the transmission network. There are also some research that provide mathematical formulations to optimize the energy systems. Different components of the systems are integrated to the formulations. For instance, for centralized systems, sector based energy demands [1] can be used whereas for rural area electrification, voltage drops and batteries [2] can be considered as necessary components of the systems.

In this research, we work on the electrical transmission network design problem with the integration of RES. We find a network configuration with the locations and types of the plants and substations, power flowing in each period that satisfies constraints related to transmission network (capacity, power loss etc.) to minimize the total investment cost. Also, in this research we aim to increase the security or reliability of the system that can occur due to the intermittency of RES by providing alternative routes for the electrical power.

References


On $k$-centrum optimization with applications to the location of extensive facilities on graphs and the like

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Keywords: ordered median problems, extensive location

This talk addresses a class of combinatorial optimization models that include among others, bottleneck and $k$-centrum and that extends further to general ordered median objective functions. These problems have been analyzed under different names for different authors in the last years ([1], [2], [3], [4], [5], [6, 7], [8] and [9]). We study the common framework that underlines those models, present different formulations and study some relationships and reinforcements. This approach leads to polynomial time algorithms for the location of extensive facilities on trees that were not previously known as for instance the $k$-centrum subtree and $k$-centrum path location on trees.

References

Capacitated Mobile Facility Location

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Keywords: capacitated facility location, column generation, branch and price

In this paper, we propose two mixed integer linear programming (MILP) formulations for the capacitated mobile facility location problem (CMFLP). The CMFLP generalizes the mobile facility location problem (MFLP), originally introduced by Demaine et al. [1], by introducing facility capacities. The CMFLP is set in a graph where clients and facilities are initially located at nodes. Destination nodes must be determined for each client and facility so that each client shares its destination with exactly one facility and the total demand of the clients allocated to a facility cannot exceed the capacity of that facility. The objective is to minimize the total weighted sum of the distances traveled by facilities and clients. There are several supply chain applications where the CMFLP arises naturally. In the context of disaster relief, an application of the CMFLP arises in determining the locations of distribution points where aid supplies are shipped from a warehouse to distribution points which in turn distributed to local aid stations.

The first MILP formulation describes a node-splitting formulation that is a straightforward adaptation of Halper et al.’s [2] formulation for the MFLP. The second MILP formulation is a set partitioning formulation where each variable corresponds to a facility to be assigned to a node with a feasible list of clients (i.e. the total demand of the clients cannot exceed the capacity). However, the set of feasible lists of clients has ex-
ponentially many elements, which requires the use of a column generation approach. We provide a computationally efficient column generation procedure where the pricing problem is solved approximately, with an exact procedure being used only when the approximate procedure fails to yield a column. We then develop a branch-and-price algorithm where the variables from the first formulation are used for branching while the second formulation and column generation procedure is used to obtain lower bounds. Finally, we offer two heuristics for the CMFLP. The first is a simple rounding heuristic that uses the optimal fractional values of the LP relaxation of the set partitioning formulation. The second is a straightforward adaptation of one of the local search heuristics in [2].

We show that the LP relaxation of the set partitioning formulation is provably better than the LP relaxation of the node-splitting formulation. Our computational experiments suggest a relationship between the quality of the LP relaxations and (i) the ratio of the number of nodes to the number of facilities, as well as (ii) the number of nodes. As the ratio gets smaller, the quality of the LP relaxation of the node-splitting formulation gets worse, a trend we do not observe for that of the set partitioning formulation. Additionally, as the ratio gets smaller, the column generation procedure runs faster which makes set partitioning the formulation of choice to obtain good quality lower bounds for these types of instances. The quality of the integer feasible solutions obtained from the set partitioning formulation follows a similar trend. As the number of nodes gets larger and the ratio of the number of nodes to the number of facilities gets smaller, the set partitioning formulation provides better integer feasible solutions given the same amount of computing time.

References


Tactical Network Planning for Food Aid Distribution in Kenya*

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Keywords: food aid, location problem, stakeholder welfare, last-mile distribution, humanitarian logistics, tactical network design

1. Introduction and aims of this paper

Sub-Saharan Africa is the only region in the world that suffers from widespread chronic food insecurity and persistent threats. In such a context, relief planning can be viewed as a tactical problem since it involves medium-term decisions reviewed every six months. Managing supply chains, where the welfare of the stakeholders is related to economical or accessibility concerns, is a complex task. Our study is motivated by a food aid distribution problem arising in the district of Garissa (Kenya), but our contribution is of general applicability to countries struggling with food insecurity.

The aim of this paper is to model and solve a practical problem arising in planning food aid assistance programs and to analyze the results. The main challenge of the project lies more in modeling the problem, in carrying out data collection and in performing analyses than in algorithmic

*We thank the Kenya Red Cross Society and the World Food Programme for their cooperation. Thanks are also due to the Canadian Natural Sciences and Engineering Research Council
development. In order to generate relevant and impactful methodological developments in humanitarian logistics, it is important to properly understand the context. Thus, the first phase of this project consisted in a field-based research to gain a better understanding of food aid distribution from an operational perspective and to gather data. This enables us to perform a careful measure of each stakeholder’s cost: the beneficiary access costs, the World Food Programme (WFP) supply costs, the Kenya Red Cross Society (KRCS) location and hand-out costs. We also make use of need assessment and GIS data to determine the distribution network parameters.

2. Results

We propose a mathematical programming based methodology to determine where to locate the distribution centers (DCs), how much food to deliver to them and which populations they should serve. Our model is a modified uncapacitated facility location problem, where covering constraints are embed by considering a constrained set of potential DC locations for a given coverage radius \( r \). Figure 1 shows the values of the objective function (total cost expressed in Kenya Shillings) as well as the values of its different terms (stakeholders’ costs) obtained by solving this model and varying the coverage radius from 5 km to 70 km. The solution that minimizes the total cost is obtained with \( r = 12 \). When considering the costs per covered beneficiary depicted in Figure 2, we observe that costs decrease as the coverage radius increases. However, the marginal costs tend to be close to zero when the coverage radius is larger than 17 km. We therefore conclude that coverage radii ranging from 10 to 17 km yields the most efficient solutions.

![Figure 1: Total and stakeholder costs as a function of the coverage radius.](image1)

![Figure 2: Cost per covered person as a function of the coverage radius.](image2)
Cournot-Stackelberg Games in Competitive Delocation

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Keywords: location, competitive delocation, Nash equilibrium

During economic crises, firms affected by the contraction in demand face the need of reducing operation costs. In the retail and service sectors, this reduction is frequently attained by means of reducing the number of facilities that the firm has in the regional market. This closure must be conducted in such a way that the market share ceded to the competitors is minimal. Moreover, in a competitive market, any decision must take into consideration the possible actions and reactions of other firms.

Even though a vast amount of literature in location theory has addressed the problem of locating facilities in a competitive environment, there is not much scientific work available on competitive delocation theory.

In this work, we propose a facility closing model in a competitive market using a game theoretical approach. We assume that two firms, competing in a duopolistic market with homogeneous products and exogenous prices, are forced to reduce their facilities’ network because of a contraction in the economic activity. We present a binary integer programming formulation of each firm’s problem and analyse the possible solutions to this non-cooperative game under two alternative settings: a discontinuous pay-off function where customers always resort to the closest facility; and a continuous one, where customers are allowed certain level of loyalty to their original provider, even if it is located farther than the closest competitor.
The game can be described as consisting of two levels. At a tactical level, the firms seek to close the subset of facilities that minimises the number of clients ceded to the competitor (i.e. the market share lost). At a strategic level, each firm considers the possible actions of its competitors and aims at maximising the market share kept after the whole restructuring process. The possible market equilibrium is analysed under three different types of competitive behaviour: Myopic, Cournot Conjectures, and Stackelberg Strategies. As the existence of equilibria in general location games on networks is hard to establish, we follow an algorithmic approach, providing a simple mechanism for finding equilibria under each of the proposed market structures, or to establish that they do not exist.

Finally, we apply the suggested technique to the analysis of a market configuration designed on an extension of the Swain network. Our results show that, even though in the discontinuous case there is no Nash equilibrium under the Cournot Conjectures, once customer loyalty is considered in the model it is possible to find Nash equilibria for the Cournot game. On a different vein, our experiments show that under the Myopic and Cournot conjectures the facilities that remain open tend to be more spatially concentrated that under Stackelberg strategies.

References


Periodic Location Routing Problem: An Application of Mobile Health Services in Rural Areas

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Keywords: mobile health services, periodic, location routing

In today’s world, health services provided to the people living in rural areas are significant. Since primary and preventive healthcare centers are not that common in these areas, a system that has been called “mobile health services” was developed. In this system, doctors, family physicians, general practitioners, nurses and other medical staff are responsible for travelling the villages at specific times and frequencies and providing primary healthcare services.

In most of the countries, mobile health services are provided and their applications change according to the countries’ healthcare policies. In Turkey, mandatory mobile health services started officially in 2010 with family physicians. It is estimated that each family practice center is responsible for covering approximately 10 villages. In other words, there are family practice centers in 9% of the villages and the remaining 91% needs to be served by mobile health services [1].

The aim of this study is to generate a cost efficient service schedule for mobile family physicians to provide service to the villages. According to the regulations on mobile health services, Ministry of Health in Turkey defined required frequency of visits to the villages based on their populations [3]. There are also other requirements in this system. For instance, the time intervals between the visits must be fixed. In other words, for the villages where service requirement is more than once a week, services must be provided at the same slot of each week. Another thing is that the service of a doctor to a village is dedicated, meaning that if a doctor is assigned to a village once, then s/he will be responsible for that village continuously. The locations of the hospitals (start and end points) are also not known.
Therefore, each doctor’s home base (origin hospital) will be assigned, i.e. will be a decision variable.

According to these inputs, healthcare services are provided to villages by doctors, whose routes will be decided on a monthly basis, and the locations of the hospitals are also decided. Hence, this problem can be defined as a location routing problem (LRP) in the operations research literature. Since the visits of these doctors have a repetitive structure in each week, the service they are providing is periodic. Therefore, this problem is also known as a special case of vehicle routing problem (VRP), which is the periodic VRP (PVRP). As a result of these characteristics of the problem, it can be said that this project is a combination of both areas, which is the periodic LRP (PLRP).

Research on the PLRP is limited. Prodhon, 2011 defines the objective as determining the set of depots to be opened, the combination of service days to be assigned to customers and the routes originating from each depot for each period of the horizon, in order to minimize the total cost.

The common characteristic of all existing studies in PVRP and PLRP literature is that the schedules are fixed. In other words, one has to give fixed schedules to the problem and the solutions are generated according to these predefined schedules. However, in our study, we aim to generate optimal periodic schedules for each doctor with a mathematical model (without defining fixed schedules as given parameters in the model). To the best of the authors’ knowledge, no such study exist in the PVRP or PLRP literature, thus, we developed a new mixed integer mathematical model which determines the locations of the hospitals, assigns each village to dedicated doctors, fixes the time intervals between the visits and creates a periodic schedule/route for each doctor.

To conclude, we are addressing a problem, which has received limited attention in the literature, and motivated from a real life application in Turkey. We are proposing a new mathematical model to the literature. The preliminary results are obtained by utilizing the optimization software CPLEX version 12.5 and they are promising. The details of the model and the solution performances over real life data sets are going to be discussed during the presentation.

References

Quintile Share Ratio in a linear city

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Keywords: quintile share ratio, analytical location model, linear city

1. Introduction

This paper focuses on the inequality measure “Quintile Share Ratio (QSR)” and applies QSR to evaluate inequality in accessibility to facilities in a linear city. QSR is an inequality measure of income distribution defined as “the ratio of total income received by the 20\% of the population with the highest income (top quintile) to that received by the 20\% of the population with the lowest income (lowest quintile)” \cite{2}.

Drezner et al. \cite{1} recently investigated interesting single facility location problems using QSR in the context of obnoxious facility location where the inequality in distances to the facility are considered. In Drezner et al. \cite{1}, the value of QSR are analytically derived at specific points such as the center of a circle and a rectangle, and vertices of a rectangle. Also, the paper mainly focuses on single facility location problems.

The aim of the present paper is to derive the value of QSR analytically in a linear city for one- and two-facility cases using the problem formulation presented in Drezner et al. \cite{1}. Explicit formulations for QSR are presented as functions of facility locations. Using this result, we can analytically evaluate inequality in accessibility to facilities for any pair of facility locations.

2. Model

We present a straightforward method to derive QSR in a linear city of length \(l\) when two facilities are located at \(x_1\) and \(x_2\). It is supposed that de-
mands are continuously and uniformly distributed along the line segment, and each demand uses the nearest facility. We first derive the cumulative distribution function of the distance, \( s \), to the facility, \( F(s|x_1, x_2) \). Then we identify \( s_1 \) and \( s_2 \) such that \( F(s_1) = 0.2 \) and \( F(s_2) = 0.8 \). By definition, \( \text{QSR}(x_1, x_2) \) is given as follows:

\[
\text{QSR}(x_1, x_2) = \frac{\int_{s_2(x_1, x_2)}^{s_{\max}(x_1, x_2)} sf(s|x_1, x_2)\,ds}{\int_{s_1(x_1, x_2)}^{s_2(x_1, x_2)} sf(s|x_1, x_2)\,ds}, \tag{1}
\]

where \( s_{\max}(x_1, x_2) \) is the maximum value of \( s \), and \( f(s|x_1, x_2) \) is the probability density function of \( s \). The value of \( s_1 \), \( s_2 \) and \( s_{\max} \) as well as \( f \) are dependent on \( x_1 \) and \( x_2 \), and all possible forms of \( \text{QSR}(x_1, x_2) \) have to be carefully identified. In total, 18 cases exist with each having different forms of \( \text{QSR}(x_1, x_2) \) and we derived them all.

As an example, Fig 1 shows a linear city where facilities are located at \( x_1 = 0.3l \) and \( x_1 = 0.6l \) (left), and its corresponding CDF, \( F(s|x_1, x_2) \) (right). The set of points where the distance to a facility is within the largest 20% is shown in thick black segments while that within the smallest 20% is indicated by thick gray segments. In this particular example, we obtain \( \text{QSR}(0.3l, 0.6l) = 12.5 \) by calculating Eq (1). We analytically derived the value of \( \text{QSR}(x_1, x_2) \) for all possible \( (x_1, x_2) \).

![Figure 1: A linear city where facilities are located at \( x_1 = 0.3l \) and \( x_1 = 0.6l \), and its corresponding CDF, \( F(s|x_1, x_2) \)](image)

References


Analysis and optimization of digestate supply networks in Bavaria

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Keywords: multi-objective optimization, supply network design, digestate

A simultaneous high density of livestock farms and anaerobic digestion plants (ADPs) may lead to a recycling competition between manure and digestate in agricultural production. In regions with intensive livestock breeding the excess of the primary nutrients from manure, phosphorus (P), nitrogen (N) and potassium (K) can be exacerbated by the application of digestate on grassland and arable land [2]. Moreover, the forthcoming revision of the Fertilizing Application Ordinance in Germany will extend the current upper limit of 170 kg N/ha for the application of N from animal excreta to all organic fertilizers including energy crops digestate [2]. This will eliminate the application of digestate on agricultural land as the primary recycling option in aforementioned regions. The thermo-catalytic reforming (TCR\textsuperscript{®}) developed by the Fraunhofer UMSICHT provides an alternative option to convert the excess digestate into high-value products (oil, gas, and char) [1]. However, since the energy and nutrient density of digestate is low the supply network design plays a crucial role for the successful implementation of innovative concepts.
The results of a preliminary analysis focused on the surplus of renewable energy and nutrients in Bavarian municipalities serve as basic input for the survey of possible regional networks consisting of potential digestate supplying ADPs and TCR® plant locations in terms of available amounts of digestate, transport distances and road links. The optimization has been carried out for a TCR® plant capacity of 300 kg/h dried digestate. Subsequently, configuration scenarios consisting of the endogenous parameters pretreatment technology and transport device as well as the exogenous parameter nutrient prices are developed. Finally, multi-objective programming, i.e. scalarization, based on the conflicting criteria system costs (economic), CO₂-emissions (ecological) and number of cross-town links (societal) is applied to the different configuration scenarios and the possible regional networks in order to determine the optimal digestate supplying ADPs and location of the TCR® plant. The required weights of the criteria are determined by an expert-based Analytic Hierarchy Process (AHP) in order to enable the calculation of a single objective function value.

References


Relationships between Demand-and-Supply Balance Indecies and Unfairness Minimization

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Keywords: Demand-and-supply balance, Service providing system

Various kinds of commercial and public services are widely provided to enrich people’s quality of life in today’s society. Especially, the public services such as fire, ambulance and medical services partially or entirely supported by tax or subsidy should be provided evenly, effectively, and efficiently to all people as possible. The variety of models are proposed and analyzed in order to evaluate the quality of public services with an objective of providing better services in the facility location literature.

To evaluate fairness, efficiency and sufficiency of the provided public services in target community, supply quantity per capita and/or per unit area can be simply used. This method is straightforward and easy to understand; however, the results largely depend on the size of each divided region.

Another possible measure to evaluate the quality of services is the min-sum criterion. Using this criterion, the facilities providing services are evaluated how close to the customers. In the models, customers are assumed to visit a facility to receive some sort of services, hence, closer facilities are more convenient for customers.

In addition to distance measure, supply capacity should be incorporated into the models. If a facility does not have enough supply capacity, it may not provide enough services even if it is close to customers. Ukai and Sasaki\textsuperscript{[1]} proposed new indices for evaluating spatial demand-and-supply balance. They also proposed an iterative method to obtain the indices by
virtually allocating supply capacity of each facility to each customer located within a certain distance. Some numerical results are presented on maps, where the number of hospital beds and the population in Kanagawa Prefecture are used as supply and demand, respectively.

In this paper, we show some mathematical properties of the proposed new indices. More precisely, we show that the sequence of solutions generated by the proposed iterative algorithm converges to a solution. We also discuss the relationship between the solutions and those obtained by solving a mathematical programming problem with an objective of minimizing the variance of indices. The objective corresponds to minimize unfairness among customers.

References

Towards the Exact Solution of Industrial Design Problems

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Keywords: MIP, large scale problem, industrial design problem, closed loop layout

1. Industrial Design Problems

Industrial design problems are optimization problems (designed/generated/configured/used) to determine the structure of production, trade or any other system. Whenever the best configuration is obtained, it is used in the long term. Thus, an industrial design problem is solved only once, before the establishment or reconfiguration of a system. Most of the location and layout problems are typical industrial design problems. There are optimization problems which are not industrial design problems. For example, the control of the same system may require an optimization problem solution frequently, for example daily. If a system is not designed in an optimal way, then some extra costs will be incurred over a long period. Thus, it is worth investing serious computational effort in the solution of such a problem. Many industrial design problems are difficult to solve exactly.

This paper describes the solution of a difficult and large scale industrial design problem. It is a benchmark problem for a closed loop layout with 10 cells. The generalization of the method is also discussed. Numerical results obtained on other benchmark problems are also mentioned.
2. The Method

The constraints of the problem are provided in [1]. However the objective function is not exact in that paper. An exact problem formulation is provided in [2]. The solution method is a “Meta-Branch and Bound” procedure; this means that the original problem is divided into sub-problems and the sub-problems are solved by a professional solver. Thus, an enumeration scheme is built above the traditional branch and bound. There are some important practical issues of the method as follows. The selection of the sub-problems is based on the local importance of the variables. A variable which creates effectively solvable sub problems in one position can be ineffective in another position; 86.8 percent of the sub-problems are fathomed by using the 73.9 percent of the total CPU time. The CPU time which is required for the solution of a sub-problem cannot be forecasted a priori. However the lower bound of the objective function can be estimated by a function of type

\[ f(t) = pt^q \]

where \( p \) and \( q \) are two parameters and \( t \) is the CPU time. The parameters must be estimated during the run. If the current function gives a very long CPU time until the target value is obtained then new sub-problems must be created. These and further technical details which will be discussed in the paper can be used in the case of other difficult industrial design problems.

References


Optimal combination of road blocking for improving evacuation time from tsunami

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Keywords: Tsunami, evacuation time, road block, genetic algorithms

After the disaster of huge tsunami at Sanriku Coast in March 2011, the research of the way to escape from tsunami is focused in Japan. In this research, we restrict using the car and set a goal of minimization of total time of evacuation taking into account all evacuees.

1. Background and Purpose

On March 11th, 2011, the big earthquake occurred in the waters off Miyagi, Japan and huge tsunami came to Sanriku seacoast. After this disaster, research of the way to escape from tsunami has become particularly relevant. In Japan, the government asks people to escape from tsunami not using their car, but walking instead. However, many people used their cars to escape to hills after the big earthquake in December 2012 and, as a result, many traffic jams occurred.

In related studies, Sasa et al. [1] suggested the optimum allocation of temporary shelters using mathematical programming. Also, Takada et al. [2] stated that the main reason why a large number of people sustained damages from the tsunami following the great east Japan earthquake was that were not able to escape smoothly using car because of traffic jams. However, there aren’t many earlier studies taking consideration of traffic jams in the case of tsunami evacuation.
From this background and earlier studies, we suggest to block several road links and make it inconvenient for people to use their car in the case of emergency. People can walk through blocked road, but cars are not allowed. As a result of this suggestion, we can expect that people will tend not to use the car in the case of emergency and the number of links which cause traffic jams will be decreased. In this research, we minimized total time of evacuation considering the choice of the way to escape.

In this research, we consider Shizuoka city in Japan for example and take in network of this city. Then, we also set the area of water exposure consulting the city’s hazard map. Evacuees should escape from solid line area to broken line area in Figure 1. To calculate optimal combination of road blocking, we used Genetic Algorithms because there are huge combinations in Shizuoka city’s network.

In initial condition, it takes 9.41 minutes in average for evacuation, but it takes only 4.91 minutes after optimal road blocking. The thick lines in Figure 1 show the links which should be blocked.

![Figure 1: Result of combination of road blocking in Shizuoka City](image)

**References**


A Branch and Price Approach for Routing and Refueling Station Location Problem

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Keywords: refueling station location, routing, branch and price, non-simple paths

Due to economic, security and environmental concerns associated with fossil fuels, the penetration of alternative fuel vehicles into the transportation network is on the rise. One of the foremost barriers to the wide adoption of this novel technology is the lack of alternative fuel refueling stations. The high cost for the initial setup of this refueling infrastructure motivates the refueling station location problem (RSLP) which is the main topic of this study. In this respect, we concentrate on the RSLP with routing considerations of the individual vehicles. In our research, we present the refueling station location problem with routing (RSLP-R) for locating a given number of refueling stations for alternative fuel vehicles in a road network so as to maximize the total flow covered. Driver deviations from the shortest path up to a certain tolerance value are considered as alternative paths including non-simple ones. The problem is practically important due to fact that the adoption of AFVs strongly depends on the availability of the refueling infrastructure and the high cost of this initial investment motivates the efforts for the best use of limited resources. It is theoretically challenging because the problem is NP-Complete and previous formulations of similar problems failed to handle large networks due to their modeling structures. The most important contribution of this work is extending the size of the solvable problem instances. Rather than pregenerating all the path alternatives before solving the model, we apply a branch and price solution algorithm which enables us to handle problems that were not of manageable size by previous works in similar contexts. Our algorithm also decreased the solution times with respect to previous studies which is an-
other major contribution to the literature. The efficiency of the solution technique is mainly due to the path-segment definition in our formulation. Such a formulation enables us to relax the simple path assumption and admits a very natural representation of the side constraints on the path. Our path-segment formulation is general enough to accommodate a wide array of side constraints on the vehicle routes other than refueling and total distance. As such, our formulation could be quite useful to model more realistic and complex problems as well as problems in completely different contexts in telecommunications and transportation.
The Design of Capacitated Intermodal Hub Networks with Different Vehicle Types *

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\textbf{Keywords:} hub location, hub network design, service network design, intermodal transportation networks

Hub location problems deal with choosing the sites of hub facilities and allocating demand nodes to hubs in order to route the traffic between origin-destination pairs. Hub location and hub network design problems, on the other hand, determine which hub links to establish between hub nodes and the routes on the hub network, in addition to determining location and allocation decisions. In other words, hub network design and routing decisions are inherently integrated in hub location problems, which have broad applications in transportation and telecommunications network design.

In this study, we approach hub location problems from a service network design perspective and allow using alternative transportation modes and different types of vehicles in the hub networks to be designed. The aim of the problem is to minimize total costs while determining the location and capacities of hubs, allocation of non-hub nodes to hubs, which hub links to establish, and how many vehicles of each type to operate on these hub links to route the demand between origin-destination pairs. There is a

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given fleet size and it is possible to rent additional vehicles to expand it. It is assumed that each vehicle operates on a single connection. Capacity of a hub is defined as the total number of vehicles of each type which can be handled at the hub.

We develop a mixed-integer programming formulation of the problem. The objective function of the model includes hub establishment costs, transportation costs, vehicle operating costs, vehicle renting costs, and material handling costs at hubs. Hub establishment costs include the land and building costs, and vary according to the capacities of the hubs to be established. Transportation costs include the fuel costs and the operational costs of different types of vehicles. Vehicle operating costs include the driver and the maintenance costs. Vehicle renting costs include the renting cost of different types of vehicles.

We propose a local search heuristic for the solution of this problem and present extensive computational analysis on the CAB and Turkish network data sets.

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<table>
<thead>
<tr>
<th>Author</th>
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<th>Email</th>
<th>Page</th>
</tr>
</thead>
<tbody>
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<td></td>
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<td>61, 59</td>
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<td>63</td>
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<td>91, 117</td>
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<tr>
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<td>65</td>
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<td>111</td>
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<td>31</td>
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<td>39, 97</td>
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<td>97</td>
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<td>51</td>
<td></td>
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</tbody>
</table>
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Absolute p-center location, 39  
Agglomeration, 95  
Alternative-fuel vehicle, 91  
Ambulance location, 87  
Analytical location model, 109  
Appointment waiting time, 89  
Bi-level optimization, 69  
Bi-objective optimization, 53  
Branch and price, 101, 119  
Branch & bound, 69  
Capacitated facility location, 19, 101  
Civil security, 59  
Closed loop layout, 115  
CO$_2$ emissions, 45  
Column generation, 101  
Competitive delocation, 105  
Congestion, 23  
Continuous demand, 31  
Cooperative cover, 87  
Coverage probability, 87  
Covering, 31, 35, 73, 75  
Covering tour, 37  
Data Visualization, 41  
Decision support, 29, 55  
Demand-and-supply balance, 113  
Digestate, 111  
Disaster planning, 43  
Discrete location, 17, 19, 57, 61, 77  
Dynamic, 71  
Edge-based demand, 31  
Electricity transmission, 97  
Energy, 47  
Evacuation time, 117  
Evolutionary algorithms, 93  
Expected distances, 83  
Extensive location, 99  
Facility location, 39, 89  
Fireworks displays, 65  
Food aid, 103  
Forecast accuracy, 79  
Fuel station location, 91  
Genetic algorithms, 95, 117  
Global optimization, 33, 69  
Green logistics, 45  
Healthcare sector, 35  
Heuristic, 17, 51, 71, 75, 91  
Hub location, 23, 25, 81, 121  
Hub network design, 121  
Humanitarian logistics, 43, 103  
Hypergraph, 95  
Industrial design problem, 115  
Integrated problems, 61  
Intermodal transportation networks, 121  
Lagrangean duals, 49  
Lagrangian relaxation, 57  
Large neighborhood search, 53  
Large scale problem, 115  
Last-mile distribution, 103  
Layout problem, 67  
Linear city, 109
Location, 35, 47, 73, 75, 103, 105
Location-assignment, 49
Location on networks, 33, 69
Location problem, 83
Location routing, 27, 37, 45, 51, 71, 107
Logistics, 55
Map labeling, 77
MINLP, 33
MIP, 115
Mixed distances, 73
Mixed Integer Nonlinear Programming, 41
Mobile health services, 107
Modeling, 67
Multi-directional local search, 53
Multinomial logit model, 89
Multi-objective optimization, 111
Multiple allocation, 23, 25
Multiple objectives, 95
Multistage 0-1 stochastic, 49
Multistage mixed 0-1 stochastic, 47
Nash equilibrium, 105
Network design, 39, 75, 97
Network flows, 63
Network location, 63
Network optimization, 29
Networks, 73
Non-simple paths, 119
Open field, 67
Optimal view points, 65
Ordered median problems, 99
OR in health services, 85
Parallel computing, 91
Park + Ride, 95
p-center problem, 21
Periodic, 107
Personnel management, 93
P-graph, 29, 55
P-median, 57
Preventive health care, 89
Probabilistic, 21
Public events, 59
Public facility planning, 85
Public transport, 95
Quality of care, 89
Quintile share ratio, 109
Random utility, 89
Rectangular Maps, 41
Refueling station location, 119
Reliability models, 19
Renewable energy, 97
Results, 104
Road block, 117
Robustness, 81
Routing, 119
Scheduling, 93
ScheLoc, 61
School districting, 51
Service network design, 121
Service providing system, 113
Service time limit, 23
Shelter site location, 43
Single allocation, 23, 25
Sink location, 63
Small world network, 79
Social network, 79
Software, 29, 59
Solid angles, 65
Stackelberg problem, 69
Stakeholder welfare, 103
Stochastic, 71
Stochastic optimization, 43
Stochastic programming, 17
Supply chain network design, 53
Supply network design, 111
Tactical network design, 103
Time-dependent parameters, 25
Transversal, 95
Tree, 27
Tsunami, 117
Uncertainty, 81
Uncertainty modelling, 85
Vehicle routing, 37