RED DE LOCALIZACIÓN Y PROBLEMAS AFINES

International Workshop on Locational Analysis and Related Problems

X Anniversary of the Spanish Location Network

MTM2010-12053-E

Torremolinos (Málaga), Spain

June 19-21, 2013

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Preface

Dear colleagues,

The ***International Workshop on Locational Analysis and Related Problems - X Anniversary of the Spanish Location Network*** is organized by the **Spanish Location Network,** which is a group of more than 140 researchers distributed into 16 nodes corresponding to several Spanish universities. Every year, the Network organizes a meeting to promote the communication between its members and between them and other researchers, and to contribute to the development of the location field and related problems. The last workshop took place in Granada, May 10-12, 2012 (http://www.webs.ulpgc.es/locafin). This year, the Network combines the organization of the annual Workshop with the celebration of its 10th anniversary, extending the call for papers to the scientific community.

The topics of interest are ***location analysis and related problems***. It includes location models, networks, transportation, logistics, exact and heuristic solution methods, and computational geometry, among others. Selected papers will be published in the journal **Annals of Operations Research**.

We wish all of you an enjoyable stay in Malaga and a successful meeting.

The organizing committee.

Committees

Scientific Committee

José Miguel Díaz Báñez
Elena Fernández Aréizaga
José A. Moreno Pérez
Justo Puerto Albandoz
Dolores R. Santos Peñate

Organizing Committee

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Justo Puerto Albandoz (US)
Antonio M. Rodríguez Chía (UCA)
Dolores R. Santos Peñate (ULPGC, coordinadora)
Rafael R. Suárez Vega (ULPGC)

General Information

Place

The meeting will take place in Hotel SOL PRINCIPE, Torremolinos (Málaga, Spain).

Information for speakers

The total time allocated to each speaker is 20 minutes, including time for questions and audience participation.

Lunches

Lunches will be held at the hotel.

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Timetable

WEDNESDAY 19	
18:00-18:30	Registration
18:30-19:00	Opening Session
THURSDAY 20	
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11:00-11:30	Coffe Break
11:30-12:30	Mark Daskin Integrating inventory into a new approach to capacitated facility location modeling
12:30-13:30	Session ULL-UPM1
13:30-15:30	Lunch
15:30-17:10	Session UM
17:10-17:40	Break
17:40-19:00	Session URJC
Permanent exhibition of posters	
FRIDAY 21	
9:00-10:20	Session US-EIO
10:20-11:20	Jack Brimberg New local searches for continuous location problems
11:20-11:50	Coffe Break
11:50-12:50	Jorge Urrutia Local algorithms on geometric graphs, and their applications to wireless networks
12:50-13:30	Session US1
13:30-15:30	Lunch
15:30-17:10	Session US2-UPM2
17:10-17:30	Break
17:30-18:30	Session UCa-UCM
18:30	Closing Session-Reunión de la Red de Localización
Permanent exhibition of posters	

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Program

Wednesday 19

18:00-18:30 Registration
18:30-19:00 Opening Session

Thursday 20 (morning)

9:00-11:00 Session UPC-EIO
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María Albareda-Sambola, **Juan A. Díaz**, Elena Fernández
An exact algorithm for the capacitated p-center problem with multiple allocation

Sibel A. Alumur, Stefan Nickel, **Francisco Saldanha-da-Gama**
A robust-stochastic model for the hub location under uncertainty

Igor Averbakh, Oded Berman, **Jörg Kalcsics**, Dmitry Krass
Structural properties of Voronoi diagrams in facility location problems with continuous demand

Isabel Correia, **Stefan Nickel**, Francisco Saldanha-da-Gama
Multi-product capacitated single allocation hub location problems: formulations and inequalities

Cristina Núñez, Elena Fernández, Jöerg Kalcsics, Stefan Nickel
Policies for the multi-period collection scheduling problem

María Albareda-Sambola, Yolanda Hinojosa, Alfredo Marín, Justo Puerto
A new model for the location of unreliable facilities

11:00-11:30 Coffee Break

11:30-12:30 Invited speaker

Mark Daskin
Integrating inventory into a new approach to capacitated facility location modeling

12:30-13:30 Session ULL-UPM1
Chair: Eligius Hendrix

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Multi-objective restricted dynamic vehicle routing problem with time windows

Eusebio Angulo, Ricardo García-Ródenas, José Luis Espinosa-Aranda
A lagrangian relaxation approach for expansion of a highway

Natalia Ibáñez-Herrero, Álvaro García-Sánchez, Miguel Ortega-Mier
A column generation approach for a comprehensive crew scheduling problem

13:30-15:30 Lunch

Thursday 20 (afternoon)

15:30-17:10 Session UM
Chair: Blas Pelegrín

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Locating a semi-obnoxious facility in the plane

Pascual Fernández, Blas Pelegrín, Algirdas Lančinskas, Julius Žilinskas
Solving competitive location problems for novelty customer choice rules

Eligius M.T. Hendrix, José Fernández, Blas Pelegrín
On bi-level aspects in continuous competitive facility location

Alfredo Marín, Juana L. Redondo, **Pilar Ortigosa**
A parallelized Lagrangian relaxation approach for the discrete ordered median problem

Blas Pelegrín, Pascual Fernández, María Dolores García
A location model for firm expansión with binary customer behavior

17:10 17:40 Break

17:40-19:00 Session URJC
Chair: Antonio Alonso-Ayuso

Laureano Escudero, María Teresa Vespucci, María Bertocchi, Stefano Zigrino
A risk averse multistage stochastic mixed 0-1 optimization model for power generation expansion planning in the long term

F. Javier Martín-Campo, Antonio Alonso-Ayuso, Laureano Escudero, N. Mladenovic
A variable neiborhood search approach for solving MINLP problems. A pilot case for aircraft conflict detection and resolution problem

María Albareda-Sambola, **Antonio Alonso-Ayuso**, Laureano F. Escudero, Elena Fernández, Celeste Pizarro
Fix-and-relax-coordination for a multi-period location-allocation problem under uncertainty

Celeste Pizarro, Laureano F. Escudero, María Merino, Gloria Pérez
Fix-and-Relax Coordination (FRC). A metaheuristic for solving large scale multistage stochastic location facilities – demand assignment problems

Friday 21 (morning)

9:00-10:20 US-EIO
Chair: Dolores R. Santos-Peñate

Rafael Blanquero, Emilio Carrizosa, **Amaya Nogales-Gómez,** Frank Plastria
Two competitive location models on networks

Emilio Carrizosa, **Carmen-Ana Domínguez-Bravo**, Enrique Fernández-Cara, Manuel Quero
Locating and sizing heliostats in solar power tower systems

Emilio Carrizosa, **Vanesa Guerrero**
Locating k-dimensional subspaces with sparse basis

Emilio Carrizosa, **Alba V. Olivares-Nadal**, Pepa Ramírez-Cobo
A location-inventory model with autoregresive demand

10:20-11:20 Invited speaker

Jack Brimberg
New local searches for continuous location problems

11:20-11:50 Coffee Break

11:50-12:50 Invited speaker

Jorge Urrutia
Local algorithms on geometric graphs, and their applications to wireless networks

12:50-13:30 Session US1
Chair: Justo Puerto

M.C. López de los Mozos, J. Puerto
Some problems on locating a single facility on the plane and a rapid subtree on a tree network

V. Blanco, S. El-Haj Ben-Ali, **J. Puerto**
Continuous multifacility ordered median location problems

13:30-15:30 Lunch

Friday 21 (afternoon)

15:30-17:10 Session US2-UPM2
Chair: Francisco Ortega

David Canca, **Alicia De-Los-Santos**, Juan A. Mesa, Gilbert Laporte
Metro network design problem

José M. Díaz-Báñez, M. Korman, **P. Pérez-Lantero**, I. Ventura.
Optimal location of a service facility and a transportation device

David Canca, Eva Barrena, Francisco Ortega
Inserting special services into regular railway timetables

Luis Cadarso, Ángel Marín
A new formulation for large-scale rapid transit network design problems

Luis Cadarso, **Ángel Marín**
Robust rapid transit network design againts disruptions

17:10-17:30 Break

17:30-18:30 Session UCa-UCM
Chair: Antonio Rodríguez-Chía

Inmaculada Espejo, Alfredo Marín, Antonio M. Rodríguez-Chía
Robust location of emergency centers by possible disruption

J. Puerto, A.B. Ramos, A.M. Rodríguez-Chía, **M.C. Sánchez-Gil**
Flexible hub location problems with capacity constraints

Begoña Vitoriano, Gregorio Tirado, F. Javier Martín-Campo, M. Teresa Ortuño
Multicriteria flow models for disaster relief operations

18:30 Closing Session
Reunión de la Red de Localización

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Pablo Dorta-González, María Isabel Dorta-González, Dolores Rosa Santos-Peñate, Rafael Suárez-Vega
Research status and trends in Operations Research and Management Science journals: a bibliometric analysis based on Web of Science database 2001-2012

Herminia I. Calvete, Carmen Galé, José A. Iranzo
The biobjective capacitated m-ring start problem

Juan A. Mesa, Francisco A. Ortega, Miguel A. Pozo, Justo Puerto
Rescheduling railway timetables in presence of passenger transfers in transportation networks

Dídac Ruiz-Hernández, Laureano Escudero, David Delgado-Gómez
A stochastic mixed 0-1 formulation for the capacitated branch restructuring model

Rafael Suárez-Vega, José Luis Gutiérrez-Acuña, Manuel Rodríguez-Díaz
Addressing the spatial nonstationarity in the Huff model parameters using Geographically Weighted Regression

Abstracts

Invited speakers

New local searches for continuous location problems

Jack Brimberg

Dept. of Mathematics and Computer Science,
The Royal Military College of Canada.

Some new ideas for conducting local searches in continuous location problems are presented. First we examine some variants of Cooper's well-known alternating algorithm. These include (i) a transfer follow-up step once a local optimum is reached, and (ii) solving larger sub-problems in the re-location step of the heuristic. In the second part of the talk we examine a new idea for exploiting the relation between the continuous model and its discrete counterpart. A local search is first conducted in the continuous space until a local optimum is reached. It then switches to a discrete space that represents a discretization of the continuous model to find an improved solution from there. New points found in the continuous phase are added to the discrete model in each iteration to improve the discrete approximation. The process continues switching between the two problem formulations until no further improvement can be found in either. The proposed local searches are applied to the multi-source Weber problem where some encouraging computational results are obtained.

Integrating inventory into a new approach to capacitated facility location modelling

Mark S. Daskin, Kayse Lee Maass, Siqian Shen

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Ann Arbor, MI 48104, USA

Capacitated facility location models constitute one of the key building blocks of facility location modeling. Previous capacitated location models will be reviewed and their key limitations will be identified. A new approach that integrates inventory management and facility location modeling will then be proposed. The new approach is motivated and facilitated by the explosion in the availability of massive amounts of transactional data. Computational results on small to medium sized problems will be provided. The presentation will conclude with an outline of possible approaches to solving larger problem instances.

Local algorithms on geometric graphs, and their applications to wireless networks

Jorge Urrutia

Instituto de Matemáticas
Universidad Nacional Autónoma de Mexico

A planar geometric graph G is a planar graph embedded on the plane in such a way that all of its edges are represented by non-intersecting straight line segments. In this talk we will review and study problems of the following type: Suppose that we have an agent that is traveling in a geometric planar graph G, and that at each vertex of G, we have available its position, i.e. its coordinates, and the positions of its neighbours. We will also assume that each node does not know anything about nodes in G that are not its neighbours, and that we are not allowed to broadcast information about the vertices of G. Although these conditions seem to be extreme, they are motivated by real-life networks that are dynamical, and whose topology is
changing all the time.

Suppose further that our agent can remember only the positions of a constant number of vertices of G plus, for all practical purposes, constant amount of data. Notice that under these assumptions, at any point in time, our agent has a limited knowledge of G. To topple things, our agent is not allowed to leave marks or any information on the vertices or edges of G. Under these conditions, one might wonder if there is anything meaningful we con compute with our agent.

Surprisingly, the answer is YES, we can. For example, if our agent wants to traverse from a node u to a node v of G, it can do it in linear time. He can also find a cycle that traverses all of the edges and vertices of G. We will also show how these results apply to routing problems in wireless networks, e.g. sensor and cellular networks, in which the topology of the networks is dynamic, and thus changes all the time.

Sessions

(in alphabetic order of first author)

Fix-and-Relax-Coordination for a Multi-period Location-Allocation Problem under Uncertainty

Maria Albareda-Sambola[1], Antonio Alonso-Ayuso[2], Laureano F. Escudero[2], Elena Fernández[1], and Celeste Pizarro[2]

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Abstract. A multi-period discrete facility location problem is introduced for a risk neutral strategy with uncertainty in the costs and some of the requirements along the planning horizon. A compact 0-1 formulation for the Deterministic Equivalent Model of the problem under two alternative strategies for the location decisions is presented. The model is solved by using the Fix-and-Relax-Coordination scheme. This solution scheme is based on a specialization of the Branch-and-Fix Coordination methodology, which exploits the Nonanticipativity Constraints and uses the Twin Node Family concept. The results of an extensive computational experience allow to compare the two alternative strategies and assess the effectiveness of the proposed approach versus the plain use of a state-of-the-art MIP solver.

Keywords: location-allocation, multi-period stochastic 0-1 programs, fix-and-relax coordination

1 Fixed-Period Problems: The Sublinear Case

Discrete facility location decisions often have long lasting effects. Frequently, such decisions can be planned as a set of sequential actions to be implemented at different moments of a given time horizon. This has led to the study of different types of multi-period facility location problems, which have been addressed by numerous authors (see [1, 3, 5], among others).

Broadly speaking, multi-period location problems are related to the evolution of dynamic organizations. Typically, such problems look for sequential location/allocation decisions that fulfill certain coverage levels of demand points at each time period. In some real situations in which non-essential facilities have to be located, budget limitations prevent from imposing full coverage from the first time period, and minimum coverage levels at the different time periods are imposed instead. Then, full coverage is only required at the end of the planning horizon. See [1] for more elaborate discussions on modeling aspects of this type of problems.

In the *Multi-Period Stochastic Facility Location Problem* (MPSFLP) we assume a set of potential facilities (e.g., production plants) and a set of customers are also given. At each time period, some customers have demand of service, which must be satisfied from open facilities. Thus, at each time period, two types of decisions must be made: the location of the facilities to open and the allocation of customers to open facilities. Uncertain data include facility set-up and maintenance costs as well as customers assignment costs. Furthermore, requests for service from the customers are not known *a priori*, as they may arrive at any period with a given probability. Moreover, the minimum number of facilities to open, and the minimum number of allocated customers for open facilities are also uncertain. In the MPSFL we consider a risk neutral strategy. That is, the objective is to minimize the overall expected costs, which in our case, in addition to the above mentioned costs, include penalties for unsatisfied service requests.

The deterministic version of the MPSFLP assumes that all the data are known in advance and historical data are used to forecast their values in the near or medium-term future. However, in practice, the actual behavior of the system is not deterministic. This leads naturally to consider stochastic programming counterparts of these problems, where historical data are used to estimate the probability distribution that governs the customers behavior. This is specifically the focus of this paper in which we address the MPSFLP, a discrete facility location problem in which some data are uncertain. In this paper the uncertainty of the MPSFLP is handled via a set of scenarios.

The special structure of each formulation is exploited by solving it with a *Fix-and-Relax-Coordination* (FRC) algorithm [4], which is a specialization of the *Fix-and-Relax* heuristic embedding a *Branch-and-Fix Coordination* (BFC) two-stage solution algorithm [2]. An extensive computational experience for a set of instances randomly generated is presented.

References

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An Exact Algorithm for the Capacitated p-center Problem with Multiple Allocation

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In this work we study the Capacitated p-center Problem with Multiple Allocation ($CpCPMA$) that considers the following situation. We have to partition a given set of users or demand points into exactly p clusters. Each cluster is charaterized by the location of its service center, with a given known capacity, and its set of users or demand points. There is a given distance of each demand point to each potential service center and the objective is to minimize the maximum distance among all the users and the centers that serve their demand. Throughout we use the term *coverage radius* of an open service center to denote the maximum distance from the center to any of the users that it serves. We also assume that it is not required that service to each demand point be provided from a single service center and, therefore, it is allowed that different service centers can serve demand of one user. The single source allocation version of the capacitated p-center has been studied by different authors, but, to the best of our knowledge, the $CpCPMA$ has not been studied in the literature. Applications of the $CpCPMA$ incude the location of emergency facilities such as blood banks with respect to hospitals, the location of fire stations, etc., where service requests from a user can be served from different facilities.

We propose a formulation for the $CpCPMA$ related to the one proposed in Elloumi, Labbé and Pcohet (2004) for the uncapacitated p-center problem. In the proposed formulation, togheter with the classical location variables, additional binary variables are used to indicate the maximum distance between a user and the center that serves its demand. However, the classical allocation variables are not considered in the proposed formulation. Instead, we use covering capacity constraints in order to ensure that service centers have enough capacity so as to serve the demand of all users within the coverage radius. Therefore, the solution for the proposed model does not provide information regarding the allocation of demand points to service centers. However, a feasible allocation of demand points to the selected service centers can be easily obtained by solving a transportation problem.

The set of coverage capacity constraints is of exponential size on the number of users. Therefore, cut generation is considered to solve the proposed formulation. To this end, such constraints are studied and several families of additional valid inequalities are proposed. We also address the separation problem for these inequalities.

In order to reduce the size of the formulation, the value of several binary variables associated with different values of coverage radii can be fixed if lower and upper bounds of the optimal solution of the problem are provided beforehand. A procedure to obtain initial lower an upper bounds on the optimal solution of the problem is also described.

In order to study the pefromace of the cut generation procedure to solve the proposed formulation an the heuristic procedure used to obtain initial lower and upper bounds, we use different set of instances for the capacitated p-median problem from the literature. These experiments are twofold, on the one hand, we test the efficiency of the proposed algorithm, and, on the other hand, we study to what extent the solutions of the $CpCPMA$ differ from those of the Single Source Capacitated p-Center Problem.

References

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A new model for the location of unreliable facilities

Maria Albareda-Sambola[1], Yolanda Hinojosa[2], Alfredo Marín[3], and Justo Puerto[4]

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The recent literature on discrete facility location includes several references concerned with reliable facility location. That is, with facility location problems where it is explicitly considered that facilities might fail with a certain probability.

Most of those references consider classical location problems, such as the p-median, but with a modified objective function to account for the expected service cost when one facility fails and its assigned customers must be served from elsewhere. In this paper we present a completely new problem, called the p-next center problem (pCP) that aims at identifying system configurations that guarantee small service distances both, when all established facilities work properly and also when one of them fails. This new problem considers the system from a center perspective and it does not require any knowledge about the facility failure probabilities (although, if desired, they could be taken into account quite easily).

It is also frequent in the reliable facility location literature to assume that the customers have complete information on the facilities status. Therefore, it is often considered that, if a facility fails, a customer will go directly form his home location to the available facility that is closest to him. As opposite, in the pCP it is assumed that customers do not know beforehand whether their closest open facility (from now on, *reference center*) is available or it has failed. Therefore, customers travel first to their reference center, and they only know whether it has failed when they reach it. When this happens, they move to the open facility that is closest to their reference center. From now on this second facility will be referred to as the *backup center*. The goal of the pCP is to identify a set of p facilities that minimizes the distance associated with the longest path from a customer to its backup center going through its reference center.

More formally, we are given: *i)* a set of points $A = \{1, \dots, n\}$ which represent customers and also candidate sites for locating the centers; *ii)* distances $d_{ij} \geqslant 0$ for each pair (i, j), $i, j \in A$ that satisfy $d_{ii} = 0$, $i \in A$, $d_{ij} > 0$, $i, j \in A$, $i \neq j$, and $d_{ij} \leqslant d_{ik} + d_{kj}$, $i, j, k \in A$, and *iii)* the number of centers that can be installed, $p \geqslant 2$. Then, the pCP is to find

$$\min_{\substack{Q \subset A \\ |Q|=p}} \max_{i \in A} \left\{ \min_{j \in Q}\{d_{ij}\} + \min_{j' \in \arg\min_{j \in Q}\{d_{ij}\}} \min_{\substack{k \in Q \\ k \neq j'}}\{d_{j'k}\} \right\}.$$

In this work we present four different formulations of the pCP, based on different sets of binary variables used to characterize the solutions. As opposite to the p-center problem, in this situation, for a given customer it might be profitable to choose as its reference center a facility that is not the one closest to it, that is, for $i \in A$ and a set of open facilities $Q \subset A$ it might occur that $\min_{j \in Q}(d_{ij} + \min_{k \in Q \setminus j} d_{ik}) < \min_{j \in Q}\{d_{ij}\} + \min_{j' \in \arg\min_{j \in Q}\{d_{ij}\}} \min_{\substack{k \in Q \\ k \neq j'}}\{d_{j'k}\}$. Since we are assuming that the first choice of a customer is made before knowing whether the reference center is working or not, the reference center of a customer must be among its closest open centers. Therefore, in the four proposed formulations we need to guarantee that the primary assignment of any customer is to one of its closest facilities. This needs to include closest assignment constraints to any formulation has a great impact on the difficulty of solving this problem using standard MIP solvers.

The four proposed formulations are analyzed and they are enhanced by means of valid inequalities and some variable fixing rules that make use of valid upper and lower bounds. After that, they are compared on a series of computational experiments that allow to identify what kind of formulation allows to solve the pCP more efficiently using standard solver.

A Robust-Stochastic Model for Hub Location under Uncertainty

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Keywords: Hub location, stochastic demands, uncertain fixed costs.

One aspect of major importance in many decision making problems regards the need to deal with uncertain data. Hub location problems are no exception. In fact, a hub location problem is a network design problem which is often solved as part of a strategic decision making process. Hence, the solution may have a long lasting effect and its implementation may take considerable time. Furthermore, it is often the case that such implementation must be finished before the network starts being operated. Accordingly, several parameters involved in hub location problems may not be accurately known when the network design decisions are made. This is typically the case with the set-up costs for the facilities as well as with the demands to be transported between the nodes.

Regarding the set-up costs, although they may be estimated before the decision is made, in practice, the actual set-up costs will vary due to many factors such as the price of the property (e.g. for land acquisition) and the price of the raw-materials (e.g. for constructing facilities).

As far as the demands are concerned, it can also be estimated in advance. However, the time elapsed between the moment the decision is made and the moment the network starts operating may make such information obsolete. Furthermore, demand may be stimulated or discouraged by the advent of the new facility. In any case, demands are hardly deterministic or known too much in advance.

In this paper, we address hub location problems under uncertainty in the set-up costs and in the demands. We aim at presenting generic models capturing the uncertainty associated with the data. By performing computational analysis, we analyze the changes in the solutions with different sources of uncertainty. Our aim is to get an insight on how relevant a modeling framework comprising uncertainty aspects may be in hub location problems. Similar to the analysis in Lium et al. [2], we study how solutions obtained under uncertainty differ from the solutions based on deterministic data. We consider discrete type of uncertainty where uncertainty is represented by a finite set of scenarios.

Several papers can be found in the literature addressing uncertainty issues in the context of hub location problems. This is the case with the works by Contreras et al. [1], Marianov and Serra [3], Sim et al. [5] and Yang [6]. However, these papers do not give an insight on the impact of different sources of uncertainty on the solutions.

The targeted modeling framework for hub location under uncertainty is progressively built throughout this work. We start by considering the simplest setting which refers to uncertainty only in the set-up costs. Then, we consider uncertainty only in the demands. Finally, we consider both sources of uncertainty in a single and more comprehensive modeling framework.

A set of computational tests performed using the well-known CAB data set (O'Kelly [4]) is reported. The results show that the structure of the solutions changes when uncertainty is considered. We are able to show that the hub locations resulting from models ignoring uncertainty in the data are not optimal and that the total costs may increase a lot if the decision maker does not anticipate uncertainty. In the computational tests performed, the impact of considering uncertainty in the set-up costs seems to he higher than the impact of considering uncertainty in the demands. Note, however, that this conclusion cannot be generalized as the impact of the uncertainty in the solutions is strongly instance-dependent. Finally, our analysis also shows that considering simultaneously uncertainty in the set-up costs and in the demands led in many cases to solutions that are different from the ones obtained when no uncertainty is considered or when only one source of uncertainty is considered. This shows that the optimal solution is clearly sensitive to the inclusion of uncertainty in the model and, more specifically to the components of the data that exhibit uncertainty. Accordingly, a modeling framework embedding uncertainty is clearly worth considering in the decision making process.

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A Lagrangian Relaxation Approach for Expansion of a Highway Network

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Abstract. The problem of highway corridors location requires a huge amount of resources and so the new infrastructures are expected to provide the best possible service for the spatial demand distribution.

This work deals with the problem of improving an existing road network in the context of strategic planning, either through the creation of new stretches of highway corridors or by converting local roads into highway corridors. To address this problem we propose a fixed cost, capacitated, multicommodity network design model. In this context, it is assumed that the level of congestion is negligible (interurban highways). The stated goal is to minimize the total travel time for a fixed budget, and a known origin-destination demand matrix.

The main objective of this work is to deal with the problem of expansion of an existing highway network in which the user's routes are taken into account. This problem has been addressed with continuous location models [8]. [1] and [2] apply this methodology. In this paper, we propose discrete models in order to find a network layout that minimizes network travel cost (travel time cost). The inputs are an existing road network, the travel demand (the so-called origin-destination trip matrix) and a given budget. The output are an expanded road network and the new travel costs.

Three optimization models have been proposed [P1], [P2] and [P3]. The so-called [P1] problem is a model formulated as a network location problem and has three characteristics: i) it is formulated as a multicommodity network flow problem, but contrary to the classical origin-destination demand pairs, it considers each commodity, as the aggregation of the total demand towards the destination, ii) it is demand oriented and iii) it contemplates a fixed budget and aims at determining the infrastructure to be built. Issue i) leads to a formulation with a drastic reduction in the dimensionality of the problem. Approach ii) is usual in other contexts, such as transit network design [3], [4], [5], but not in the road location problem. This determines the model as an aid to investment in new infrastructures which will produce the greatest social benefit. Approach iii) allows us for several roads to be considered simultaneously. The solution of [P1] is a set of (disconnected) links which represent the new set of highways.

[P1] results have suggested improving the proposed model to locate a single (polygonal) highway corridor in a network. This task has been faced in two stages: (1) the so-called [P2] model locates a polygonal plus a set of disjointed cycles, and (2) the [P3] model adds to [P2] model a set of constraints to avoid the cycles. This type of problem appears independently in the design of Rapid Transit Networks (RTN) (see, for example [4] and [6]). These authors consider the problem in terms of path location on a graph. The proposed models are of great computational complexity which requires the numerical experiments described in the literature to be carried out only in very small-scale lesser a dozen of nodos [3], [5], [7].

A case study has been carried out for the region of Castilla-La Mancha (Spain), with 290 population centres and using CPLEX. The size of the problem [P1] involves $2,102,916$ equations and $38,511,259$ variables and a relative gap less than 4% have been achieved.

[P3] have been found to be computationally intractable for the case studies of 290 and 67 nodes. A lagrangian relaxation approach have been applied to [P3]. The relaxed primal problems descompose into two subproblems: i) a shortest path problem and ii) a network design problem consisting of locating a polygonal on a graph. This method is being tested on the case study.

Keywords: Multicommodity Network Design, Location Highway, Expansion Network, Lagrangian Relaxation

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Multi-Objective Restricted Dynamic Vehicle Routing Problem with Time Windows

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Abstract. The Dynamic Vehicle Routing Problem with Time Windows (DVRPTW) consists not only in finding a set of optimal routes for some vehicles in order to serve a set of customers with specific time windows, but also in readjusting the vehicle routes to add new customers that appear in real time.

We tackle a real-world application of this problem proposed by a delivery company, in which the vehicles are loaded at the beginning of the planning horizon and then the arising services are inserted into a route supposing the minimum infeasibility. The company knows all the deliveries, but only the 60% of the pick-ups. The remaining 40% is dynamic since it appears during the day. Moreover, the following constraints have to be considered. The vehicles have different capacities; each of them can have a different time window, as well as the customers; extra hours for the vehicles might be allowed; the customers have a level of priority so that they can be postponed if they have less level of priority than a fixed one; and finally, some customers cannot be served by certain vehicles due to road restrictions. Besides, the problem is zoned; a problem supposes the solution of different sub-problems.

The objective functions have been taken into account in lexicographic order, in such a way that if there is a draw between two different plans for one objective, the next one is compared. The order used in this work is: number of postponed customers, extra time used by the vehicles, total traveled distance, number of routes, total consumption and total cost.

The computational experiments have been carried out by testing the approach over the test problem instances in the related literature. Thus, we have obtained competitive results if we compare them with the best known results. Furthermore, we have generated and tested instances specifying the constraints of the real application. Finally, nowadays we are doing real tests using the 4GFlota system, which allows managing a fleet of vehicles.

Structural Properties of Voronoi Diagrams in Facility Location Problems with Continuous Demand

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The problem of finding optimal locations for a set of service facilities is of strategic importance and has generated a large body of research literature. In most models customer demand is assumed to be discrete and aggregated to a relatively small number of points. However, in many urban applications the number of potential customers can be in the millions and representing every customer residence as a separate demand point is usually infeasible. Thus, it may be more accurate to represent customer demand as continuously distributed over some region, e.g., a convex polygon. We assume that demand is uniformly distributed over a convex polygon in the rectilinear plane, facilities can be located anywhere in the polygon, and customers obtain service from the closest open facility. We focus on conditional location problems where several facilities are already open and the goal is to choose optimally a location for an additional (new) facility.

While the discussion below applies to a variety of location problems that can be defined in this setting, for concreteness consider the conditional market share problem where locations of $p-1$ facilities are fixed and we seek to find the optimal location for the remaining facility with the objective of maximizing its market share (rectilinear distances are assumed). Once the locations of all p facilities are specified, the demand space is partitioned into regions called "Voronoi cells"; the resulting partition is known as the "Voronoi diagram". The main difficulty is that it is generally impossible to represent the objective function in closed form. In fact, the representation of the objective function depends on the structure of the Voronoi diagram, i.e., the position and the geometry of the cell boundaries. Unfortunately, this structure can change drastically with the location of the "free" facility, making the underlying optimization problems quite difficult. The optimization problem is greatly simplified if the location of the new facility is restricted to a sub-region where the resulting Voronoi diagram is "structurally identical" for every point in the region. Given such regions, we can derive a parametric representation of the objective function which is valid for any location in the region. This, in turn, allows us to optimize the location of the new facility over this region using classical non-linear programming techniques. This suggests a general solution approach for this class of models: first partition the demand space into regions where Voronoi diagrams are structurally identical, then find the optimal location(s) within each sub-region; the best of these local optimal is the optimal solution to the problem.

In this talk we derive structural properties of Voronoi diagrams for the rectilinear distances and show how to use them to identify the desired sub-regions. Moreover, we discuss how to determine efficiently the parametric representation of the objective function over each region and how to solve the resulting nonlinear optimization problem. While the optimization techniques are specific to the particular model being considered, the structural results we derive, as well as our general approach, are quite universal, and can be applied to many other location models as well.

Continuous multifacility ordered median location problems

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Abstract. In this paper we propose a general methodology for solving continuous, multifacility ordered median location problems by formulating an equivalent sequence of semidefinite programs that converges to the solution of the problem. These relaxed problems can be then solved with SDP solvers to construct effectively the solutions of the original problems. We apply dimensionality reductions of the problems by sparsity and symmetry in order to be able to solve larger problems.

Keywords: Continuous Multifacility location, Ordered median problems, Semidefinite programming, Moment problem.

1 Introduction

Multifacility location problems are the most interesting problems in Location Analysis. It is well-known that even in their discrete version the p-median and p-center are already NP-hard (see Kariv and Hakimi [3].) A lot of attention has been paid in the last decades to these classes of problems, namely location-allocation problems, since they are easy to describe and to understand and they still capture the essence of difficult problems in combinatorial optimization.

On the other hand, also in the las two decades locators have devoted much effort to solve continuous location problems that fall within the general class of global optimization, i.e. convexity properties are lost. Related with the previously mentioned discrete location-allocation models there exist the continuous location-allocation problems. Here, we are given a set of demand point (existing facilities) and the goal is to locate several facilities to provide service to the existing ones minimizing some globalizing function of the travel distances. Assuming that each demand point will be served by its closest facility we are faced with another location-allocation problem but now the new facilities can be located anywhere in the framework space and therefore they are not confined to be in an “a priori” given set of locations. Obviously, these problems are much harder than the discrete ones and not much has been obtained regarding algorithms, and general convergence results, although some exceptions can be found in the literature [2] and the references therein.

Since the nineties a new family of objective functions has started to be considered in the area of Location Analysis: the ordered median problem [8]. Ordered median problems represent as special cases nearly all classical objective functions in location theory, including the Median, CentDian, center and k-centra. More precisely, the 1-facility ordered median problem can be formulated as follows: A vector of weights $(\lambda_1, \ldots, \lambda_n)$ is given. The problem is to find a location for a facility that minimizes the weighted sum of distances where the distance to the closest point to the facility is multiplied by the weight λ_n, the distance to the second closest, by λ_{n-1}, and so on. The distance to the farthest point is multiplied by λ_1. Many location problems can be formulated as the ordered 1-median problem by selecting appropriate weights. For example, the vector for which all $\lambda_i = 1$ is the unweighted 1-median problem, the problem where $\lambda_1 = 1$ and all others are equal to zero is the 1-center problem, the problem where $\lambda_1 = \ldots = \lambda_k = 1$ and all others are equal to zero is the k-centrum. Minimizing the range of distances is achieved by $\lambda_1 = 1$, $\lambda_n = -1$ and all others are zero. Lots of results have been obtained for these problems in discrete settings, on networks and even in the continuous single facility case (see the book [8] and the recent paper [1]). However, very little is known in the continuous multifacility counterpart.

In this paper, we address the multifacility continuous ordered median problem in finite dimension d and for general ℓ_p norms for measuring the distances between points. We show how these problems can be cast within a general family of polynomial optimization problems. Then, using tools borrowed from the Theory of Moments [6, 5] we show how they can be solved (approximated up to any degree of accuracy) by a series of relaxed problems each one of them is a simple SDP that can be solved in polynomial time. We present preliminary computational results and show how the sizes and accuracy of the results can be improved by exploiting some specific characteristics of these models, namely sparsity in the representing variables and symmetry [4, 7, 9].

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Two competitive location models on networks

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Abstract. Huff location problems have been extensively analyzed within the field of competitive continuous location.
In this work, two Huff location models on networks are analyzed, by considering that users go directly to the facility or they visit the facility in their way to a destination.
Since the problems are multimodal, a branch and bound algorithm is proposed, in which two different bounding strategies, based on Interval Analysis and DC optimization are used and compared. Computational results are given for the two bounding procedures, showing that problems of rather realistic size can be solved in reasonable time.

Keywords: Huff location models, location on networks, DC optimization, Interval Analysis.

A New Formulation for Large-Scale Rapid Transit Network Design Problems

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Increasing mobility, longer journeys caused by the growth of cities and congestion problems in city centers are some of the reasons why during the last years new lines of rail transit systems (metro, urban rail, light rail, etc.) have been constructed in some agglomerations, while in others, existing lines and networks have been expanded.

Due to the high cost of constructing transit systems, it is important to pay close attention to their effectiveness in solving the urban public transportation design problem. The rapid transit network design problem consists of the location of train alignments and stations, considering the current and the new network to be constructed, considering the maximization of the coverage by the new network in competence with the old one. The previous decisions are taken in a context where the demand makes its own decisions about the network alternatives (evaluating the network design alternatives), subject to design and budget constraints. In order to provide a smart design of the network passengers' transfers between different lines must be considered.

The necessity of developing a new formulation for this problem comes from the fact that previous studies in the field of rapid transit network design have failed to solve realistic large-scale problems. We define a new integer formulation for computing tight bounds of the linear relaxation of the problem. Formulations from previous studies and the new formulation are compared in this paper.

Our computational experiments show that we are able to solve realistic problem instances in reasonable computational times. We conduct computational experiments on two different networks and perform sensitivity analysis on several model parameters.

Keywords: rapid transit, network design, transfers, large-scale.

Robust Rapid Transit Network Design against Disruptions

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Designing a rapid transit network or even extending one that is already functioning, is a vital subject due to the fact that they reduce traffic congestion and passenger travel time. A rapid transit network design problem is faced where usually another transportation system is already operating. Therefore competition between the rapid transit network to be constructed and the alternative mode must be taken into account in the model.

Transport network design is highly dependent on the future system usage. We want to design a network as cheap as possible such that the number of travelers using the rapid transit network is as high as possible. The users will use the new network if they find it more attractive than the alternative one.

The rapid transit network design problem tries to maximize the demand coverage by the new network subject to design and budget constraints, but considering the user decisions to evaluate the network design alternatives. These decisions must consider two alternatives, the old and the new (to be constructed) networks.

During the operation of a rapid transit network service disruptions usually occur. We may design a network which remains feasible even for the worst-case scenario, a robust network. However, a robust network design may be expensive to be operated in regular daily basis. A low utilization of the infrastructure occurs if the network is designed considering the possible disruptions, using a big budget in its construction.

We propose an approach to recoverable robustness network design using a minimize-maximize formulation as an alternative to robust design avoiding the use of probabilities for every disruption, which are always difficult to estimate. The model is formulated for minimizing the maximum deviation of a given set of disrupted scenarios. Computational experiments on realistic large-scale problem instances demonstrate that the developed model and methodology can be used to solve large networks.

Keywords: recoverable robustness, network design, rapid transit

The Biobjective Capacitated m-Ring Star

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Abstract. The capacitated m-ring star problem consists of finding a set of m simple cycles (rings) starting and ending at a central depot so that each node of the network is either in a ring or is connected to another node or to some Steiner point present in a ring. The rings must be node-disjoint (except for the central depot) and the total number of nodes assigned to a ring (in the ring or connected to a node in the ring) is limited by the capacity of the ring. The goal is to minimize the total cost which is the sum of the ring cost (due to the links of the rings) and the allocation cost (due to the connections to nodes in the rings) (Baldacci et al. (2007); Hoshino and Souza (2012); Naji-Azimi et al. (2010, 2012)). In this work we present the biobjective capacitated m-ring star problem in which both costs are considered individually. In order to approximate the set of nondominated outcome vectors or Pareto front, we propose a hybrid evolutionary algorithm which uses heuristics to construct feasible solutions from the information provided by the chromosome.

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Inserting special services into regular railway timetables

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Abstract. Train scheduling is the third step in the classical hierarchical approach to railway services planning. Regular timetabling has been widely used by railway and subway companies around the world. Under this approach, quality of service is quite related with trains headway and capacity. Headway (and its inverse, frequency) is perhaps the more important design decision. Once fixed the headway, the optimal capacity can be obtained. Unfortunately, this procedure leads to low occupancy levels from a spatial and temporal point of view. That is, some of the scheduled trains run with low occupancy levels at different segments of the lines whereas trains are highly occupied in others segments. Design strategies that guarantee reasonable users' waiting time and improve train occupation diminishing operation costs is then an important topic in this field. Traditionally, two main pure off-line strategies to deal with such kind of situations have been used: Short-turning and deadheading. The first one is usually used when only a few of high demand stations should be attended. With this strategy, some vehicles perform short cycles in order to increase the frequency in certain stations of the lines.

This paper proposes a tactical model to determine optimal policies of short-turning and non-stopping at certain stations considering different objectives like minimizing the passenger overload and preserving certain level of quality of service. The model enables to obtain both periodic and non-periodic timetables. Computational results for a real case study and comparisons with previous approaches are provided.

Keywords: Railway, Scheduling, Timetabling, Acceleration strategies, Short-Turning

1 Introduction

The aim of the global transit planning process is the definition of a set of lines and the determination of their associated timetables to which vehicles and drivers are assigned. Disruptions can appear frequently due to an increase of the demand, infrastructure incidences or as a consequence of fleet size reductions. These circumstances give rise to un-supplied demand at certain stations and consequently passenger overloads in the available vehicles. Thus, designing strategies that guarantee admissible users' waiting time while maintaining reasonable operation costs are fundamental objectives of the robustness analysis of Rapid Transit Systems (RTS).

Short-turning is a tactical strategy which is useful when high demand zones need to be serviced. Following this strategy some vehicles can perform short cycles in order to increase frequency in specific zones of the line. Short turning can be applied to different trains that those included in the standard timetable, i.e., special trains or shuttles that perform short cycles sharing tracks with the scheduled trains. A second strategy for alleviating overloaded stops consists of skipping stops (deadheading) at those stations with less demand.

In normal RTS operational circumstances, trains follow a periodic scheduling, stopping at each station according to a cyclic timetable. When vehicles arrive at the last station, they repeat the same itinerary in the opposite direction and so on. Periodic scheduling has been widely used by authors like Liebchen and Möhring (2002), Liebchen and Peeters (2002,2009), Liebchen (2004) and Chierici et al. (2004) , especially in the metropolitan railways context.

2 Hierarchical modelling approach

Designing the best timetable to attend the demand described by the demand increment origin-destination matrix can be decomposed in two different decision problems. By one side, considering that the company have certain number of available shuttles, the first decision is the selection of services, i.e. which of actual services should be reinforced if there are not sufficient shuttles to serve all the necessities. Once selected the most convenient services or after ordering the priority to attend each one, the second part is the design of proper timetables inserting adequately the new services into the existing ones. Although the problem can be treated as a whole, here we propose a decomposition in two separate and consecutive problems, so that the first one allows us to fix origin and destination of services which have to be inserted into existing timetables and the second one to obtain arrival and departure times of shuttles, both problems are formulated with similar objectives: move as many passengers as quick as possible.

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Metro network design problem

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Abstract. The planning process in public transportation consists of several consecutive phases, starting with the network design, followed by line planning, timetabling and and crew and rolling stock scheduling. We concentrate on the network design in the context of a metro system. In our model, the innovative point with respect to current literature is the inclusion of frequency and capacity in the design of a metro network, as well as the consideration of elasticity of the demand. More concretelly, this work proposes a new design model which includes transfers between train lines, budget constraint, limitation in costs, location and allocation constraints, frequency and capacity constraints. The objective of the model is maximizing the profit of the network. A mode of transportation competing with the metro network to be designed is considered. It is assumed that the mobility patterns are known but the demand may vary according to the service offered by the system. In other words, the demand is presumed to be elastic and, therefore, it changes according to modifications in the characteristics of the system such as frequencies, topological configuration, line definition, etc. Computational results are reported.

Keywords: Network design, Frequency, Capacity.

1 Introduction

In recent years, much effort has been devoted to constructing, improving or extending rapid transit network. This phenomenou is motivated by the increased mobility, traffic congestion, the growing length of trips and by the need to reduce energy consumption and pollution (see Gendreau et al. (1995)). Is important to pay attention to the investment in the construction of new networks due to their very high cost and because these networks cannot easily be modified within a short time horizon.

In this work we will focus on network design. The main novelty of this work is the consideration of a general model that contains as particular cases, all models treated in the literature related with this problem. In addition, in this model frequencies and capacities are considered. Thus, the problem combines two intertwined problems: transit network design and transit network frequencies setting (see Guihaire and Hao (2008)). In a general manner, the problem under study consists of deciding at which nodes of a network to locate the stations, how to connect them and in determining a set of lines, each one formed by two terminal stations, a sequence of intermediate stations (an itinerary) and their frequencies. We call the network to be designed *the public network or the public mode*. The input data are the potential location for the stations, the distance matrix between pairs of stations, the travel patterns, construction costs and capacity related costs.

In order to model the problem realistically, it is necessary to assume that there exists a different mode of transportation competing with the public system (e.g. private car, bus, bicycle) which we will call *the alternative mode*. It is assumed that the demand may vary depending on the service offered by the system (see Kepaptsoglou and Karlaftis (2009), Ranjbari et al. (2011)). That is, the demand is supposed to be elastic and changes by modifying the characteristics of the system related to service frequency, topological configuration, line definition, etc. This assumption of elastic demand is formulated by means of an elastic demand assignment function. Usually, the system is defined for peak hours and the service is adapted during the other periods.

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Locating and sizing heliostats in solar power

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Abstract. A method for optimizing solar power tower systems is proposed, in which the heliostats location and size are simultaneously considered. Maximizing the efficiency of the plant, i.e., optimizing the energy generated per unit cost, leads to a difficult high dimensional global optimization problem with an objective function hard to compute and non convex constraints as well.
The optimization problem and a greedy-based heuristic procedure to solve the problem will be described.

Keywords: solar thermal power, heliostat field layout, thermo-economic optimization, global optimization, greedy algorithm, heuristics.

Locating k-dimensional subspaces with a sparse basis

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Abstract. Given a data set U in the n-dimensional space, Principal Component Analysis (PCA) seeks a k-dimensional affine subspace S minimizing the sum of squares of the Euclidean distances between the points in U and their projection onto S.
PCA dates back to the earliest years of the 20th century, [4], and is nowadays a powerful tool in Data Analysis and a source of research, [2]. In particular, much effort has been made to address *sparse* PCA, in which S is sought to have a sparse orthornormal basis. Several authors relate the notion of sparseness with the number of zero coordinates that appears in the resulting vectors, [5],[9], while others assume that coordinates must belong to any particular set (for example, integers), [7], [8].
In this talk we shall review some of the methods in the literature on sparse PCA and will introduce our proposal, rs-Sparse Principal Component Analysis, [1]: S is sought so that the number of nonzero coordinates in the basis is bounded by a fixed integer. The resulting problem is written as a mixed integer nonlinear program, tackled via an ad hoc heuristic. Computational results on data sets from the literature,[6], will be presented. These results are compared against the ones given by VARIMAX, [3], Simple Component Analysis, [7] and Sparse Principal Component Analysis, [9]. It is shown that our procedure outperforms these ones in several cases.
The strategy proposed attempts to minimize errors while keeping sparseness above a given threshold value. A problem of simultaneous optimization of sparsity and error minimization, parametrized by the total number of non-zero coordinates in the resulting vectors, is also studied. Numerical experiments show that this biobjective approach is also competitive against other procedures.

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A location-inventory model with autoregressive demand

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In this talk we address a p-facility location-inventory problem in which the demand of each user is not known, but assumed to be given by a time series following an autoregressive process.

A robust approach will be followed: We have to determine which p locations to choose in order to maximize the worst-case total revenue on a planning horizon. Since the future demand is unknown, it will be forecasted from historical records by means of a robust autoregressive model. The inventory will be managed as a newsboy inventory model, in which costs considered are production costs (at the facility), transportation costs (from the facility) and sell price.

Structural properties of the problem will be presented. Since we do not have a closed formula for evaluating the total profit, an heuristic will be proposed to solve this problem.

The methodology will be illustrated with some numerical examples.

Multi-product capacitated single allocation hub location problems: formulations and inequalities

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In a hub location problem, a set of nodes is given such that some flow must be shipped between them. The goal is to select a subset of the nodes to become hubs i.e., to consolidate and redistribute the flow. By doing so, significant gains can be achieved in terms of the efficiency of the whole system namely in terms of the costs as it is possible to take advantage from economies of scale by consolidating and redistributing the flow using the selected hubs and the links between them.

Typically, in the literature devoted to hub location problems, a single type of flow is considered. However, in practice, this is often not the case and multiple products are to be shipped between each pair of nodes. When the different types of flow are to be consolidated and redistributed using a set of hubs, we obtain a multi-product hub location problem. This is the situation we address in this talk.

When more than one product exists in a transportation network, two situations may arise: either each product calls for specific handling facilities and for different distribution channels or the products can share handling facilities and distribution channels. One example for the first case regards people and containers in harbors whereas, for the second situation, we can think of letters and parcels in a mail system.

Accordingly, depending on how much the products differ, we can distinguish between dedicated hubs and non-dedicated hubs. In the former case, each hub can handle exactly one product; in the latter, one hub can handle more than one product.

When we have dedicated hubs we can make one additional distinction: i) in each node more than one dedicated hub can be installed; ii) in each node at most one dedicated hub can be installed. The first case, leads to a multi-facility location problem: more than one facility can be installed in each location (node). It is straightforward to see that in this case, we can decouple the problem in terms of products and we obtain a set of classical single product hub

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location problems. Accordingly, the existing models and methodologies for tackling 'classical' hub location problems can be used directly.

When we have dedicated hubs but at most one hub can be located in each node the above decoupling is not possible and specific models must be considered for the problem. The same happens if the hubs are non-dedicated.

In this work, hubs are assumed to be capacitated. In particular, it is assumed that the capacity constraints refer to the non-processed incoming flow to the hubs. Accordingly, we are considering types of flow that once processed, can be routed to the destination without further processing. Nevertheless, due to its specificity, each product can only be shipped through hubs handling the product.

For each product we assume a complete hub network as it has often been considered in the hub location literature. However, note that the whole hub level network is not necessarily a complete network.

In this talk we propose a unified modeling framework for multi-product capacitated single allocation hub location problems (MP-CSAHLP) when at most one hub can be located in each node. Our modeling framework comprises simultaneously the case in which hubs are dedicated and the case in which hubs are not. We present and discuss several mixed-integer programming formulations for the problem and propose several additional inequalities for enhancing the lower bound provided by the linear relaxation of each of these models.

The problem addressed in this talk can be seen as an extension of the well-known capacitated single allocation hub location problem. This is a problem that has been addressed in the literature by several authors.

Optimal location of a service facility and a transportation device

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Suppose that we have a set of clients represented as a set of points in the plane, and a service facility represented as a point to which all clients have to move. Every client can reach the facility directly or by using an alternative highway h, represented by a straight line segment of arbitrary orientation, in order to reduce the travel time. A client travels at speed $v > 1$ on h and at speed 1 in the L_1 metric elsewhere.

We address the cases in which the highway's length is fixed by the user (or can be modified to further decrease the transportation time) and consider two types of highways: *freeways* and *turnpikes*. The difference between a freeway and a turnpike is that a client can only enter or exit from a turnpike at its endpoints, while it can enter and exit from a freeway at any point of it (see Figure 1).

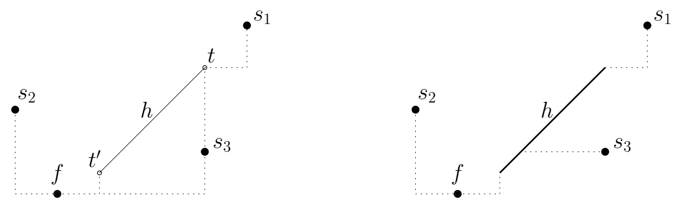

Figure 1: The left (resp. right) figure shows the distance model using a turnpike (resp. freeway). In the first case s_1 uses the turnpike in order to reach f faster. The turnpike does not speed up transportation between s_2 and f, hence is not used by s_2. Demand point s_3 however, can either walk or use the turnpike to reach f, and will need the same time in both cases. In the right we have the exact same instance, but the highway is now a freeway. Observe that in this case, point s_3 will take profit from the freeway. Observe that, since we are interested in paths that reach f, h will only be used in one direction.

We study the following facility location problems: Given the set of points representing the clients, determine at the same time the facility point and the highway that minimize either: a) the *total weighted travel time* from the clients to the facility, where the *weighted travel time* of a client is its travel time multiplied by a weight representing the intensity of its demand; or b) the *largest travel time* between the clients and the facility.

We summarize the time complexity of our algorithms solving these problems in the following table:

	length	$\sum$	max
Turnpike	fixed	$O(n^3)$ [1]	$O(n^2)$ [2]
	free	$O^*(n^4)$	$O(n \log n)$ [2]
Freeway	fixed	$O(n^4)$ [3]	$\Theta(n \log n)$ [2]
	free	$O(n^3)$ [3]	$\Theta(n \log n)$ [2]

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Research status and trends in Operations Research and Management Science journals: a bibliometric analysis based on Web of Science database 2001-2012

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1 Introduction

The subjects *Operations Research* (OR) and *Management Science* (MS) (even though there may be philosophical differences, we use the two terms interchangeably), have been defined by many authors in the field. Definitions range from "a scientific approach to decision making" to "the use of quantitative tools for systems that originate from real life" (Eiselt & Sandblom, 2010). The Institute for Operations Research and the Management Sciences (INFORMS) defines OR/MS as the "science of better". What all of this essentially means is that the science uses quantitative techniques to make and prepare decisions, by determining the most efficient way to act under given circumstances.

During decades, the *journal impact factor* (IF) has been an accepted indicator in ranking journals, however, there are increasing arguments against the fairness of using the IF as the sole ranking criteria. In this sense, many possible modifications and improvements have been proposed (Bornmann & Daniel, 2008; Dorta-González & Dorta-González, 2013a,b).

Journal performance is a complex multi-dimensional concept difficult to be fully captured in one single metric (Moed et al., 2012, p. 368). This resulted in the creation of many other quality metric indices such as the *fractionally counted impact factor* (Leydesdorff & Bornmann, 2011), *scimago journal ranking* (González-Pereira et al., 2009), *h-index* (Hirsch, 2005), and *central area index* (Dorta-González & Dorta-González, 2010, 2011) to name a few.

Some studies have been carried out on particular aspects of OR/MS (Chang & Hsieh, 2008; White et al., 2011). But these studies were mainly based on analyses of a part, meanwhile there is no report to analyze the research status and trends of the academic field as a whole.

2 Materials and methodology

The bibliometric data was obtained from the online version of the *Web of Science* database (Science Citation Index) during the last week of february 2012. All journals listed in the subject category of OR/MS were considered. The impact factors (IF) of the journals were obtained from the year 2011 Journal Citation Reports (JCR), which were the latest data available.

In the intention to measure and evaluate the scientific progress at the research front, we have focused on the research articles which are the primary font of the research results. Collaboration type was determined by the addresses of the authors, where the term "internationally collaborative publication" was designated to those papers that were coauthored by researchers from more than one country. Similarly, the term "inter-institutionally collaborative publication" was assigned if authors were from different institutions.

3 Results and discussion

We obtained some significant points on the global research performance through the period from 2001 to 2012. The number of papers consistently increased in this period. Especially, it was the fast-growing period of 2004–2009 which the growth rate reached 18%. *Expert Systems with Applications* published the most papers not only in the past twelve years but also in 2012, while *Journal of Operations Management* had the highest h-index and IF. The citation maturity time in the category OR/MS is greater than two years and the production follows the Bradford's law with five journals in the core.

Among the top 20 countries/territories were nine in Asia. The USA ranked first in terms of total, single country and internationally collaborative publications. However, the collaborative papers represented only 33.6% of the total publications from the USA, which was least than more of other countries in the top 20. The publication impact of the USA was excellent with the highest h-index (114) among all the countries, followed by China (66) and Canada (62). Among the top 20 institutions were ten in America and nine in Asia. The University of California has strongly independent research ability and less desire to collaboration with other institutions in OR/MS. Among the top 20 most productive authors, ten were from China, five from USA/Canada, and the rest from other Asian countries.

The mainstream research in OR/MS is mainly focused on "networks", "control", "simulation", and "production", although "genetic algorithms" might be one of research hot topics in the coming years.

4 Conclusions

We have tried to measure the scientific progress in the discipline. These results could help to better understand the global development of the discipline, and potentially guide scientists for evaluating and orienting their research.

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A risk averse multistage stochastic mixed 0-1 optimization model for power generation expansion planning in the long term

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Abstract. We present a mathematical model for hedging the profit's maximization of a price-taker power producer who has to decide the power generation capacity expansion <ndx plants location planning in a long time horizon under uncertainty of the main parameters. These parameters are the variable production costs of the power plants already owned by the producer and the candidate plants of the new technologies to select; the market electricity price along the horizon, as well as the price of green certificates and CO2 emission permits; the potential market share that can be at hand for the power producer. These uncertainties are represented in a multistage scenario tree (whose stages are individually included by consecutive years whose constraint systems must be satisfied). The stochastic model a mixed 0-1 subject to technical constraints, market opportunities and budget limitation and new power plants location restrictions. The plants location assignment is defined by using 0-1 variables at the years in the related scenario groups at the stages along the given time horizon, such that the chosen plants for the candidate technologies are added to the existing generation mix. The energy production of the generation mix is defined by continuous variables at the years in the related scenario groups at the stages. The model for maximizing the net present value of the expected profit over the scenarios along the ti, namely , Conditional Value at Risk, Shortfall Probability, Expected Shortage and First- and Second-order Stochastic Dominance constraint integer-recourse strategies.

Robust location of emergency centers by possible disruption

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Abstract. This work deals with the p-center problem, where the aim is to minimize the maximum distance between any user and his reference center. The reference center for any user will be the second-closest center that will be the center where this user will be reallocated in case of failure of his closest center. Moreover, the capacity of each center must suffice to satisfy the demand of all users for which is the closest center and for the users for which is the second-closest center because these users will be also covered by this center in case of a failure of their closest center. The problem is of interest when locating emergency centers and, at the same time, taking precautions against emergencies which can cause failure of the center itself. We consider 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 for all the formulations previously presented are developed, obtaining in some cases much better resolution times.

Keywords: p-center, capacities, integer programming

1 Introduction

The p-center problem (pCP) is a well-known discrete optimization 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.

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. A recent survey on location of emergency services can be consulted in [1].

Emergency services have, in practice, a limited capacity. Consequently, capacitated versions of pCP have also received attention in the literature. In the capacitated p-center problem (CpCP), each site has a demand and a capacity and the total demand of the sites assigned to a center cannot exceed its capacity. Then, CpCP is the problem of finding the set of p locations and the assignment pattern that satisfies the capacity constraints whereas the maximum distance site-closest center has to be minimized. To the best of our knowledge only in three papers CpCP has been exactly solved: [2], where the special case of an underlying tree network is approached; [3], where an algorithm for the p-center problem is modified and extended, succeeding to provide optimal solutions in small times for small instances of the problem; and [4] where the authors propose two different Lagrangean duals and an exact algorithm capable to solve larger instances. In [5], the capacitated ordered discrete location problem is studied.

We consider a more realistic case. Sites still must be assigned to their closest centers and then any center j must have enough capacity to satisfy the demands of the sites which are closer to j than to any other center. In addition, an unpredictable incident may occur in any of the p centers forcing this center to be closed and all customers allocated to it to be reassigned to another center, which must be the second closest center with respect to the site. Consequently, the capacity of any center must be enough to receive also the sites re-assigned to it in case of failure of any other center. The goal then is to minimize the second lowest distance from a site to the set of centers, since in case of an emergency which produces a damage in one of the emergency services, all the sites should be still inside the smallest possible radius around an available center.

There is some research on discrete location dealing with facility disruptions, although it is mainly focused on stochastic assumptions, where some probability of failure is considered. In [6] an implicit formulation of the stochastic p-median problem is developed. In [7, 8] the authors provide several heuristics for the stochastic fixed-charged problem. Heuristics with bounds on the worst-case performance and the study of asymptotic properties of the solutions of the stochastic p-median problem are carried out in [9].

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Locating a semi-obnoxious facility in the plane

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Abstract. A new multi-objective semi-obnoxious facility location model is introduced. The objectives are the minimization of (1) the transportation costs from the facility to the demand points (as efficiency measure), (2) the global repulsion of the affected population centers (as social cost measure) and (3) the Gini coefficient determined by the individual repulsions (as equity measure). A multi-objective evolutionary algorithm is used to obtain a discrete approximation of its Pareto-front. Computational studies show the goodness of the approach.

Key words: Semi-obnoxious facility, nonlinear multi-objective optimization, Pareto-front, multi-objective evolutionary algorithm.

1 The model

Most decision-making problems involve more than one objective. The decision about where to set up a new facility is not an exception. This is particularly true when the facility to be located is semi-obnoxious, that is, it is attractive to some of the demand points with which it will interact, and repulsive to others. In this paper we present a new multi-objective facility location model. The first objective is the classical minsum one, where one seeks to minimize the sum of weighted distances from the facility the the demand points that perceive the facility as attractive. The second one is the minimization of the global repulsion of the demand points that consider the facility as obnoxious. The third one is an

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equity measure, and seeks that the differences among the individual repulsions is minimized.

Let A^+ be the set of points for with the new facility is attractive, and A^- the set of points for which the new facility is repulsive. Notice that $A^+ \cap A^-$ may be a nonempty set. Let w_a be a weight related to the importance of demand point $a \in A^+ \cup A^-$. The repulsion of an inhabitant living at $a \in A^-$ against the location of the facility at the point x is given by

$$rp(a,x) = \frac{1}{1 + \exp(\alpha_a + \beta_a d(x,a))},$$

where $d(x,a)$ denotes the distance between demand point a and the new facility and $\alpha_a \in \mathbb{R}$ and $\beta_a \in \mathbb{R}^+$ are two values to be estimated for every demand point a. The total repulsion at $a \in A^-$ against the new facility is given by $trp(a,x) = w_a \cdot rp(x,a)$. Then, the multi-objective problem is given by

$$\begin{aligned} &\min f_1(x) = \sum_{a \in A^+} w_a d(x,a) \\ &\min f_2(x) = \sum_{a \in A^-} trp(x,a) \\ &\min f_3(x) = \frac{\sum_{a \in A^-} \sum_{a' \in A^-} |trp(a,x) - trp(a',x)|}{|A^-|^2 \overline{trp}} \\ &\text{s.t. } \ x \in F \end{aligned} \tag{1}$$

where $\overline{trp} = (\sum_{a \in A^-} trp(x,a))/|A^-|$, and F denotes the feasible region where the new facility is to be located.

2 Obtaining a discrete approximation of the efficient set

As problem (1) is a location problem on the plane, the efficient set, as well as its image in the criterion space, the so-called Pareto-front, may be a continuum of points. Hence, we look for a discrete approximation of those sets. In particular, as we are interested in the trade-off between the three objectives, we want a finite set of points which cover the complete Pareto-front and evenly distributed over it.

Several general-purpose heuristics have been proposed in the literature with that purpose. Among them, evolutionary algorithms have been most successful, since they are able to obtain an approximating set in a single run. However, the existing methods have been designed for obtaining an approximation set given a budget in the number of function evaluations, regardless of the CPU time employed for that. In this paper we present a general-purpose multi-objective evolutionary algorithm, called FEMOEA, whose aim is to obtain a fix size approximation of the Pareto-front *quickly*. FEMOEA combines ideas from different multi- and single-objective optimization evolutionary algorithms, although it also incorporates new devices, namely, a new method to improve the efficiency of points and a new stopping rule to stop the algorithm as soon as a good approximation of the Pareto-front is obtained.

Solving competitive location problems for novelty customer choice rules [3]

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Keywords: Competitive location, entering firm, customer behavior.

1 Introduction.

The two customer choice rules commonly used in the literature on competitive facility location problems are the *binary rule* and the *Huff rule*. The first consists of the full demand of a customer is served by the most attractive facility. The second consists of the full demand of a customer is served by *all* competing facilities in proportion to the attraction to each facility. The attraction to a facility is measured by a parameter, called quality, which depends on the characteristics of the facility, divided by a nonnegative nondecreasing function of the distance between the customer and the facility. In some cases, a better estimation of the market share captured by each facility is obtained by using other customer choice rules, for instance the *partially binary rule* and the *Pareto-Huff rule*.

In the *partially binary rule*, the full demand of a customer is served by all the firms but patronizing only one facility from each firm, the one with the maximum attraction. Then the demand is split between those facilities proportionally to their attraction. Hakimi[1] proposed this rule, and more recently Surez-Vega *et al.* [3] used this rule to solve a location-quality model on networks combining a global search algorithm based on a branch and bound procedure with some combinatorial heuristics (greedy, interchange, and tabu search).

In the *Pareto-Huff rule*, a customer will patronize a more distant facility only if that facility has high quality. Thus, each customer can only be allocated to facilities that are Pareto optimal with respect to the quality (to be maximized) and the distance (to be minimized), and this set depends on each customer. So, if we denote by PH_i the set of facilities Pareto optimal for customer i after the location of the new facilities, the demand of each customer i will be split between facilities belonging to PH_i proportionally with their attraction. Peeters and Plastria [2] used this rule for competitive facility location models on networks and gave some discretization results for optimal solutions.

In this work, some competitive location models on discrete space will be considered in which an entering firm wants to locate s new facilities in order to maximize its market share when either the partially binary or the Pareto-Huff choice rule is used. Some heuristic optimization algorithms are presented to solve these problems, which allow to deal with large problems.

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2 Models.

Let consider a market area where it is supposed that customers are aggregated at n demand points, there are some competing firms C_j, $j = 1, \dots, k$, already operating in the market area, and an entering firm E wants to locate a set X of s new facilities in these market in competition with the pre-existing facilities. The following notation will be used:

w_i	demand at demand point i, $i = 1, ..., n$.
d_{ij}	distance between demand point i and facility j.
q_j	quality of pre-existing facility j.
q	fixed quality for each new facility of the entering firm.
a_{ij}	attraction that demand point i feels for facility j Usually, a_{ij} is a function of d_{ij}, for instance $a_{ij} = \frac{q_j}{1+d_{ij}}$, where q_j is the quality of facility j.
$a_i(C_j)$	the maximum attraction that demand point i feels for the pre-existing facilities of chain C_j, $i = 1, ..., n$, $j = 1, ..., k$.
$a_i(X)$	the maximum attraction that demand point i feels for the facilities of the entering firm.
L	set of possible locations for the new facilities

With the partially binary choice rule, the problem of finding the locations for the s new facilities in order to maximize the market share captured by the entering chain is formulated as follows:

$$Max\{M_{pb}(X) = \sum_{i=1}^{n} w_i \frac{a_i(X)}{a_i(X) + \sum_{j=1}^{k} a_i(C_j)} : |X| = s, X \subset L\}.$$

With the Pareto-Huff choice rule, that problem is formulated as:

$$Max\{M_{PH}(X) = \sum_{i \in I} w_i \frac{\sum_{j \in PH_i \cap X} a_{ij}}{\sum_{j \in PH_i} a_{ij}} : |X| = s, X \in L\}$$

We present heuristic controlled random search algorithms to solve the above mentioned problems. The proposed algorithms are based on single agent search and ranking of candidate locations, according to their previous fitness in forming candidate solution. The performance of the proposed algorithm will be experimentally investigated by solving different instances of the problem by using real data of geographical coordinates and populations of municipalities in Spain.

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On bi-level aspects in continuous competitive facility location *

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Abstract. Competition when locating a new facility implies a company takes into account the reaction of possible competitors leading in continuous location to interesting Global Optimization problems. The competition can also enhance setting a price or adapting the quality of a facility to attract more customers. These latter decisions are typically dealt with by bi-level thinking; optimization of the competitive prices and quality is done on a second level and substituted into a first level location decision. The bi-level thinking has been applied to study the existence of stable market situations in a Nash equilibria location situation. Moreover, in a so-called leader-follower (Stackelberg) setting, it potentially leads to tri-level analysis. We go through some of the ideas from literature.
keywords: Competitive facility location,bi-level

1 Introduction

In facility location competition, the main instrument is the choice of location. Since the first model of Hotelling [3], many extensions have been studied in competitive location science where firms basically decide on locating one or more facilities at location(s) x trying to attract market share. The strategic choice of location can be complemented by tactical decisions y such as the price of the product in location-pricing or location-quantity competition (see [8]), the quality in location-design problems like the original Huff model ([4]) or capacities of the facilities. The objective for a firm depends on a large part on the market capture of demand often represented by so called demand points. The demand can be thought of as fixed, or can be elastic, depending on the tactical decision y (price, quality, capacity), or the distance to the location x itself.

Thinking in terms of decisions on several levels may help to analyse the model and its behaviour for various model studies: Focus on one firm to maximise its profit, studying the existence of stable market situations (Nash equilibria) and finding so-called Stackelberg equilibria, where one firm is a leader and others react on that. This leads to some interesting open questions.

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2 Bi-level approach continuous facility location papers

Consider a firm that decides on location x and second level decisions in order to maximise its profit Π

$$\max_{x,y} \Pi(x,y). \tag{1}$$

In the location-design model, e.g.[2], the objective is dominated by a Huff-like model attracting market share by choosing location x and setting a quality y. Studying the second level optimisation of Π, where location x is fixed, shows that in fact Π is concave in quality y and therefore the optimum quality level $y^*(x)$ is relatively easy to find. Substitution of the second level decision provides a first level problem $\max_x \Pi(x, y^*(x))$. The same approach can be used to derive Nash equilibria in continuous location-design [7] or in location-pricing [1] [6].

A further step is to consider the second level as the follower decision in a Stackelberg two firm setting as in [9] in fact substituting the solution $x_2^*(x_1)$ of a Global Optimization (GO) problem into a GO problem $\max_{x_1} \Pi(x_1, x_2^*(x_1))$. The corresponding location-design [5] becomes tri-level, if quality is decided on tactical level. First solve Stackelberg: $y_1(x_1, x_2, y_2(x_1, x_2, y_1)), y_2(x_1, x_2, y_2) \rightarrow y_1^*(x_1, x_2), y_2^*(x_1, x_2)$ on tactical level. Solve follower problem $x_2^*(x_1)$ and substitute into first level Stackelberg $\Pi(x_1, x_2^*(x_1), y_1^*(x_1, x_2^*(x_1)), y_2^*(x_1, x_2^*(x_1))$.

One can go deeper with multi-level analysis when properties of optimal lower level decisions can be used to substitute them into the higher level decisions. We discuss our experience on this topic.

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A column generation approach for a comprehensive Crew Scheduling Problem.

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Keywords : Crew Scheduling, Column generation, Set partiotioning problem.

This paper addresses a crew scheduling problem solved through column generation in the context of a railway system. A set of activities are to be accomplished by a set of workers with the minimum cost. For every worker a duty is to be created that meets all requirements (technical, legal, etc.) It is a well-known problem that has been prevously studied. The one presented in this paper differs from the rest in a twofold sense. First, the type of activites to be attended by workers do not only consist in driving scheduled comercial trips. Second, it includes a large set of constraints to be satisfied by every duty. The quality of this solution heavily impacts the performance of the system as it highly depends on the human resources involved in its operation.

Two main approaches have been adopted in the literature to address this problem.Some authors have formulated the problem as a Set Covering Problem, where the number of elements are the activities to be performed, which are to be divided into the minimum number of subsets (duties for workers). [Abbink et al., 2005] use TURNI to generate duties according to different rules. A combination of a dynamic column generation, a Lagrangian relaxation and a heuristic is used to solve the set Covering problem.

The second approach consists in addressing the problem as a Set Partitioning problem where a set is divided into small parts and all the elements of the initial set must be in the partitions. [Desaulniers and Hickman, 2007] use this approach and divided a set of tasks which has to be done in pieces of work which are formed of blocks. The consecutive segments along a block assigned to the same driver are collectively called a piece of work. Duties are composed of pieces of work The objective is given the segments of a set of vehicle blocks, find a set of valid duties that covers all these segments and minimize total cost.

Our approach falls within the second option. As has been mentioned above we used column generation to solve the problem which is descomposed into a Master problem and the correspondig Pricing subproblem. Following, the Master problem is formulated as a Set partitioning problem.

Let S be the set of train activities to cover D the set of valid duties. Denote by C_d the cost of a duty d and by A_d^s a binary parameter that is 1 if a duty d covers an activity s, and 0 otherwise. By activities we refer to all the obligatory tasks in which ones a driver has to be present. Finally, define a binary variable $y_d \in [0, 1]$ for each duty $d \in D$ that indicates if a duty d is retained in the solution.

$$\min.\ z = \sum_{d \in \mathcal{D}} C_d y_d \tag{1}$$

$$\text{s. to:} \quad \textstyle\sum_{d \in D} A_d^s y_d = 1, \qquad \forall s \in \mathcal{S}, \tag{2}$$

$$y_d \in [0, 1] \qquad \forall d \in D. \tag{3}$$

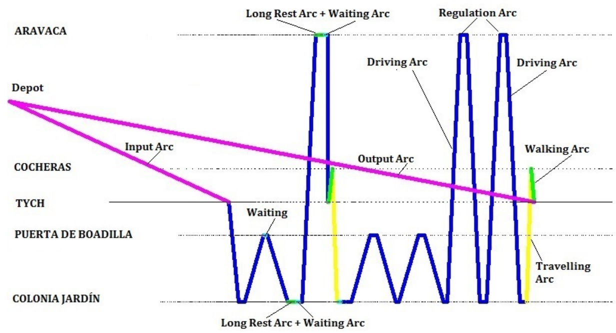

Figure 1: Example of a feasible duty

As mentioned above, a set of activities are to be performed by drivers. Driving: every scheduled trip must have a driver assigned.Regulating: for short periods of time elapsing from the end of a trip to the begining of the following one for a particular vehicle, a driver must be present at that vehicle. When this elapsed time is larger than a particular value, two operations must be performed by some driver. Prior to starting the trip, the vehicle must be set up and and after being stopped for a long period of time, the vehicle must be 'set-down'. In particular, all vehicles must be set-up for their first trip of the day and must be 'set-down' after their last trip of the day.

For drivers to be able to perform a set of the previous activities some other activities must be performed as well, namely, walking, waiting, entring and exiting the system and resting. Let us define an event e by a station s and an instant $t$where a transition in between two activities may exists. Any two events may be linked by an arc of any of the defined activity types. A duty is a path along the graph meeting a set of requirements:

Drivers start and finish their duties in the same station. The duty length is both upper and lower bounded. Only in some stations switching drivers is allowed. Starting times for duties belong to a set of discrete time windows, corresponding to a set of shifts. The drivers can only rest in some stations. All vehicles that have remained stopped for longer than a certaing time must undergo a start-up check list. All vehicles that will remain stopped for longer than that time must undergo a switching off check list. Drivers have to wait some specific time before starting to drive a vehicle in the same station in which the service starts if they have been resting or are giving a relief. There is a maximum allowed driving time that cannot be exceeded. Drivers can rest in between activities. In particular, at least a long rest of a given duration must be assigned to every duty.Last, flow conservation is to be imposed to avoid unfeasible transitions.

The objective function for the Pricing problem allows finding duties that may improve the objective function of the master problem

Figure 1 is an example of a feasible duty. It can be observed that it is composed of different arcs corresponding to different activities which have been explained above.

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Some problems on locating a single facility on the plane and a rapid subtree on a tree network

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Abstract. There are several papers dealing with location problems in which traveling distances are a combination of planar and network distances and thus model real-world situations like highway networks or other traffic infrastructures more realistically. To this end, an embedded network in the plane is used to represent a transportation system in which traveling is faster than traveling within the plane according with some planar metric. Most of these models have considered that the alternative transportation system is already located, and the corresponding location problem is formulated in order to minimize some travel distance function.

On the other hand, a different model dealing with a mixed transportation system has been studied in recent papers. In this model, the problem is focused on simultaneously locating a segment and a service facility on the plane such that the total transportation cost from the demand points to the facility is minimized. The main difference is that the segment to be located is the service itself and it is used as an alternative high-speed line.

This location model can be extended to the case in which the alternative high-speed system is selected from a given tree network. The tree network only represents the underlying space in which the high-speed substructure can be located, taking into account that out of such substructure the distance between two points will be measured by the metric considered in the plane, even if both points belong to the given tree. Several problems arise from this model depending on the planar metric considered, the type of substructure and the way that it is used, and the objective function involved.

In this work we present some of such problems by considering the planar metric is the l_1 norm, and the substructure is both a path and a star subtree. We also introduce some constraints on the length of the subtree and analyze several types of travel distances which can be made. For each case we study the problem of locating a service facility on the plane and the corresponding rapid subtree in a given tree network in order to minimize the total travel distance from demand points to the facility.

A parallelized Lagrangian relaxation approach for the Discrete Ordered Median Problem

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Abstract. We study a flexible discrete location model which has as particular cases the p-median problem, the p-center problem and the k-centrum problem, among many others. A previous formulation is adapted and a Lagrangian relaxation is carried out on this formulation in order to produce lower and upper bounds on the optimal value of the problem. The relaxed problem can be splitted into several subproblems whose resolution is simultaneously tackled by means of a parallelized algorithm. The results are compared with other methods proposed in the literature for this problem.

Key words: Discrete location,Integer Programming, Lagrangian Relaxation, Parallel Algorithms.

1 The Discrete Ordered Median Problem

Let $N = \{1, \ldots, n\}$ be a set of discrete locations that represents potential plant locations and also customers.

Let $D = (d_{ij})$ be an $n \times n$ matrix, where d_{ij} denotes the distance (travel time/cost) from location i to location j. We assume $d_{ii} = 0$ $\forall i \in N$ and $d_{ij} > 0$ $\forall i, j \in N$, $i \neq j$, although the identity of d_{ij} and d_{ji} is not required.

Let p with $1 \leq p \leq n-1$ be the number of plants to be located. Given a set of plants $P \subset N$ with $|P| = p$, the allocation distances (supplying costs) of the customers will be given by

$$d(P) := (d_1(P), \ldots, d_n(P)) \quad \text{where} \;\; d_i(P) = \min_{j \in P}\{d_{ij}\} \;\; \forall i \in N.$$

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By arranging in increasing order the elements of $d(P)$, we get the sorted distances associated to set P

$$(d_{(1)}(P), \dots, d_{(n)}(P)).$$

Let $\lambda = (\lambda_{1-p}, \dots, \lambda_{n-p})$, with $\lambda_i \geq 0$ representing a weight on the $(p+i)$-th lowest component of $d(P)$ $\forall i \in N$. Then the *Discrete Ordered Median Problem* (DOMP) is

$$\min_{\substack{P \subset N \\ |P|=p}} f_\lambda(P) = \sum_{i=1}^{n} \lambda_{i-p} d_{(i)}(P). \tag{1}$$

Note that objective function in (1) can be re-written as

$$f_\lambda(P) = \sum_{i=p+1}^{n} \lambda_{i-p} d_{(i)}(P) = \sum_{i=1}^{n-p} \lambda_i d_{(p+i)}(P),$$

since the first p addends in (1), corresponding with the p plants, will be null. Thus the p first values of λ are neglectable.

The advantage of this model is that, using appropriate values for λ, most of the classical discrete location problems are obtained as particular cases.

Since the DOMP contains the p-median problem, which is $\mathcal{NP}$-hard, as a special case, the DOMP is also $\mathcal{NP}$-hard.

Different Integer Programming formulations have been proposed for the DOMP, the most satisfactory being the one developed in [1]. A new formulation, which is equivalent to the formulation introduced in [1] but better suited to be relaxed in a Lagrangian fashion, is introduced.

2 Lagrangian relaxation

Lagrangean relaxation (LR) is a well known methodology for approaching combinatorial optimization problems. It exploits the inherent structure of the minimization problems to obtain lower bounds on the value of the optimal solution.

In formulation (MO) we fix variables to zero when possible. Then, we relax constraints in a Lagrangean fashion incorporating them to the objective function with weights given by a multiplier vector (u, v) of appropriate dimension to obtain a Lagrangean function. The resulting relaxed problem decomposes into at most g subproblems, one for each value of k for which not all z- or x-variables have been fixed to zero (i.e., $k < g' := \min\{\max_{i \in N}\{k_i^z\}, \max_{j \in H}\{k_j^x\}\}$).

Consecuently, it is possible to parallelize the algorithm in such a way that each processor executes one of the g subproblems independently of the others. This parallelization has been carried out by mean of Shared Memory processors.

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A Variable Neigborhood Search approach for solving MINLP problems. A pilot case for aircraft conflict detection and resolution problem

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In order to guarantee air traffic safety due to the growth of the demand in this field, the aircraft conflict detection and resolution is crucial for the Air Traffic Management. This problem consists of providing a new configuration for a given set of aircraft in such a way that the conflict situations are avoided. Notice that a conflict situation is such event in which two or more aircraft lose their minimum safety separation distance being 5 nautical miles and 1000 feet as horizontal and vertical, respectively. In this work we present a Variable Neighborhood Search (VNS) approach to solve the problem in which the aircraft are allowed to change only by performing turn changes. The algorithmic approach is based on the reformulation of the problem as unconstrained by using an exterior penalty function in which a geometric construction to detect the conflict situations is taken into account. The first improvement local search consists of changing direction of the aircraft by a given parameter whereas the shaking operator moves several aircraft at once by a random parameter that is based on the k-value of the VNS approach. This approach compares favourably with previous best known methods based on solving a mixed integer nonlinear optimization model by using the exact engine Minotaur for small-size instances (up to 10 aircraft) and a sequencial resolution of integer linear optimization models for up to 25 aircraft. It is worth to point out the small computing time required to solve the different testbeds of our experimentations, making this approach useful to be used in a real-life problem where the response must be given in a few seconds. A comparative study is presented and compared.

Rescheduling railway timetables in presence of passenger transfers in transportation networks

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Abstract. The problem of coordinating transfers consists of determining timetables which ensure the transfer of passengers between trains from different line runs at interchange stations. Two strategies can be considered:

- Forcing the transit lines to have to be synchronized; that is, a solution can be accepted only if the connection between them is feasible, while the goal is minimizing delays for passengers by using the minimum number of vehicles needed.

- Minimizing an objective function that penalizes the lack of synchronization between timetables of feasible lines.

The problem of coordination of transfers turns out to be NP-hard even in the simple case of periodic schedules. Therefore, the problem is usually treated sequentially in two phases: first, determine the frequency of service according to the rate of demand, and then solve the problem of coordination by means of heuristics.

This paper considers a transit line where a train fleet circulates and stops at the stations according to a predetermined schedule which is known by the users. At any instant, passengers arrive at different stations in order to board these vehicles according to a model of distribution of passenger arrivals that is assumed deterministic.

In this scenario, a service rescheduling forced by an incidence is determined in order to minimize the loss of passengers who require transfers between different line runs at the interchange stations. A study case composed of a railway line with several equi-spaced stations, where it is possible a connection to other lines at intermediate stations is analyzed for different scenarios where the loss of transfers is penalized.

Keywords: Transit network, Transport Scheduling, Disturbance management, Schedule Synchronization

1 Introduction

Many references consider Mixed Integer Problem formulations in which the arrival and departures times are represented by continuous variables and there are binary variables expressing the order of the train departures from each station. The variables chosen to formulate the model must be able to formally express all possible restrictions, so that only feasible timetables can be considered as possible solutions. There are two main criteria to assess the quality of the solutions: Minimize operating costs (point of view of the operator) and Minimize riding and transfer times (perspective of passengers). Moreover, other complementary objectives can be used, for example: minimize the passenger waiting time in the case of changeovers, balance the delay of trains in both directions, minimize the average delay of new trains with respect to their optimum, etc.

Accidents, strike days and other sources of train delays or cancellations force to modify the scheduled timetable when trains in some sections cannot run according to the initial planning. Rescheduling is the process of updating an existing production plan in response to disruptions or other changes (Vieira et al., 2003). Rescheduling is especially important in heavily used areas because individual events (delays) can easily impact many other trains causing secondary delays to ripple through the network. In order to manage this domino effect when a train is late and reduce the impact on the other trains, controllers must manually adjust the routing of trains. The effectiveness of the rescheduling and train control system at reducing total delay is highly dependent on the specific circumstances (timetable, train routes, topology of the station and tracks before in the bottleneck area).

The modification to the map should be performed without introducing inconsistencies. Research on rescheduling algorithms has been underway for many years. See, for example, the survey paper by Cordeau et al. (1998) and the recent contribution of Canca et al. (2012). We present an approach to generate acyclic timetables for single line track. This approach is based on geometrical properties associated to topology of a transit corridor (see Mesa et al., 2013**)**. Two versions are introduced: a context without considering transfers from/towards other transit lines, and a setting where the existence of transfers between lines must be preserved after rescheduling the service. In the second case, two scenarios have been formulated taking or not into consideration an equitable evaluation between the different collective of users. Theoretical development is illustrated with a non-sophisticated example in order to clarify the concepts used along the paper.

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Policies for the Multi-period Collection Scheduling Problem

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In this talk we present the Multi-Period Collection Scheduling Problem (MCSP). In this problem there exist a set of stations where containers are located. The containers continuously receive scrap material. When a container is full, it is collected by a logistic company which picks up the container and replace it by an empty one.

The logistic company has limited but enough number of vehicles to perform the visits to station and collect the containers. The fleet of vehicles is consider has an homogeneous and are available throughout a given time horizon. For every day, each vehicle may visit several stations and pick up one container from each station in the same trip, but it has a capacity limitation in terms of the maximum number of containers it can store simultaneously.

For each station, the time until the container is full strongly depends on their location. Because different collection stations may have different filling intervals, collection routes are established on a daily basis. This means that, in principle, we do not assume that periodic schedules should apply, therefore a specific collection route may take place just once throughout the time horizon and collection routes may be different for each of the days of the time horizon. Therefore, a scheduling calendar and the set of collection vehicles must be determined for the collection of the containers at the stations.

The modeling aspects of the MCSP are oriented to reduce the fleet size. This objective coincides with the current trend in scheduling and vehicle routing problems, not only for economic savings but also due its environmental benefits as well. For the MCSP, two alternative policies for the collection scheduling calendars are considered. In the first policy, called as Periodic Collection policy, the time intervals between two consecutive visits to a given collection station are always of the same length and coincide with its filling interval. With this policy, once the day of the first collection is decided for a given collection station, subsequent collection days for this station are uniquely determined.

Conversely, in the second policy, the time intervals between two consecutive visits to a given collection station are not established in advance and can be of different lengths. With this policy, for each station, all the collection days must be decided and it is therefore permitted to re-visit a collection point even before its filling interval. This feature implies the possibility of shorter time intervals. However, it is not allowed that the time between two consecutive visits to the same collection station exceeds its filling interval. The rationale behind this policy, called as Aperiodic Collection policy, is that allowing for early collections may reduce the overall number of vehicles needed throughout the time horizon, by better using the capacity of vehicles not fully used on previous periods. Of course, allowing for early collection may cause a negative effect since stations are not collected periodically and thus, it could be possibly to need additional planning at the collection stations. To reduce such effect, the Aperiodic Collection policy consider the minimization of a weighted sum of the total number of vehicles and the number of early collections.

In this work, two mathematical integer lineal programming formulations are presented, one for each collection policy. Extensive computational tests were obtained to evidence the hardness of the problem. For Aperiodic Collection policy, different values to the weight for number of vehicles and early collections were assigned to consider both criteria within different scenarios. In addition, a sensibility analysis is presented to show the usefulness for the Aperiodic Collection policy. Moreover, this analysis allows to detect the scenarios in which the Aperiodic policy is profitable for saving on vehicles.

In general, the MCSP can widely applied as a subproblem of other periodic problems in literature, for example Periodic Vehicles Routing Problems (PVRP) and Periodic Capacitated Arc Routing Problems (PCARP). Since, for this kind of problems, two decision stages are involved, the MCSP can be used in the first decision phase in which the scheduling calendars are defined.

A location model for firm expansion with binary customer behaviour [3]

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Keywords: Competitive location, expanding firm, binary customer behavior.

1 Introduction

The aim of this paper is to study the location problem in a new framework in which the existence of fixed facilities owned by some competing firms is considered and one of such firms wants to expand by locating new facilities. The new facilities will compete with each other, as well as with any existing facility, owned by the expanding chain or by any of its competitors. Therefore, the pre-existing facilities owned by the expanding chain can lose profit as a consequence of the expansion. This effect is known as *cannibalization* and it was first considered in franchise distribution systems (see [1], but it has been almost ignored in the recent location literature. Some references are the papers [2],[3],[4] and [5]. In this paper, the sharing profit model introduced in [3] is studied when the customer choose the most attractive facility .

2 The model

Let us consider several firms which provide some goods or service to a certain geographical area. One of the firms, called the expanding firm and denoted by A, wants to locate new facilities in order to increase its market share in that area. The customers are spatially separated and they patronize the most attractive facility to be served. If ties in maximum attraction for a customer occur for pre-existing facilities, then its demand is split among the most attractive facilities. For the new facilities demand is only captured from the customers for which they are more attractive than the pre-existing facilities. Without loss of generality the other existing competing firms can be considered as one firm called B.

The following notation is used:

$I = \{1, 2, \ldots, n\}$ – set of demand points;

F_A – set of existing facilities owned by firm A;

F_B – set of existing facilities owned by competing firms B;

L – set of location candidates for the new facilities;

r – number of new facilities to be located;

a_{ij} – attraction of demand point i for facility j;

w_i – demand at point i.

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ϑ_i – proportion of demand at i captured by firm A in case of tie in maximum attraction;

X – set of locations for the new facilities;

F_X – set of new facilities;

$a_i(F) = max\{a_{ij} : j \in F\}$ – maximum attraction of i by the facilities in F.

Before the expansion $I = I_A \bigcup I_{AB} \bigcup I_B$, where $I_A = \{i \in I : a_i(F_A) > a_i(F_B)\}$, $I_{AB} = \{i \in I : a_i(F_A) = a_i(F_B)\}$, and $I_B = \{i \in I : a_i(F_A) < a_i(F_B)\}$. The market share captured by firm A is:

$$ms(F_A) = \sum_{i \in I_A} w_i + \sum_{i \in I_{AB}} \vartheta_i \cdot w_i$$

The set of demand points which a captured by the new facilities after the expansion is $I(X) = \{i \in I : a_i(F_X) > a_i(F_A \cup F_B)\}$, then the market share captured by the new facilities is given by:

$$ms(X) = \sum_{i \in I(X)} w_i \tag{1}$$

Let $I_A(X) = \{i \in I_A : a_i(F_X) > a_i(F_A)\}$ and $I_{AB}(X) = \{i \in I_{AB} : a_i(F_X) > a_i(F_A)\}$, then the lost of market share of the old facilities is given by:

$$can(X) = \sum_{i \in I_A(X)} w_i + \sum_{i \in I_{AB}(X)} \vartheta_i \cdot w_i$$

We consider that firm A obtains a portion of the profit of its facilities and there is an agreement between firm A and its pre-existing facilities in order to compensate those facilities that could be cannibalized as consequence of the expansion. The agreement here is that firm A will pay an amount δ of money to any cannibalized facility per unit of lost profit. If γ is the portion of profit that the firm obtains from the facilities, then $0 < \delta \leq 1 - \gamma$, where $0 < \gamma < 1$. Then firm A is interested in solving the following optimization problem:

$$(P_{\gamma\delta}) : \qquad \max\{\Pi_{\gamma\delta}(X) = \gamma \quad (ms(F_A) + ms(X) - can(X)) - \delta\Pi_{can}(X) : |X| = r, X \subset L\}$$

We analyse this problem and present an ILP formulation for solving the problem in discrete location space. A sensitivity analysis of optimal locations is shown.

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Fix-and-Relax Coordination (FRC). A metaheuristic for solving large scale multistage stochastic location facilities – demand assignment problems

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In this paper we present a parallelizable Fix-and Relax Coordination algorithm for providing (hopefully, good) solutions for multistage mixed 0-1 optimization problems under uncertainty that arise in location problems, where the locations and capacity of the facilities should be selected and the customer demand should be assigned to the facilities allowing demand splitting among the facilities under certain conditions. The uncertainty is represented via a symmetric scenario tree, and it can appear at any stage along a time horizon. The information structuring for scenario cluster partitioning of symmetric scenario trees is also presented, given the general model formulation of a multistage stochastic mixed 0-1. Given the huge dimensions of the problem, the decomposition approach that appears most promising is based on some forms of branching selection, and scenario cluster partitioning and bounding that definitively use the information about the separability of the problem. One of its special features is the information structuring for generating, saving and manipulating the scenario cluster submodels in a mixture of splitting variable and compact representations. Given the structuring of the scenario clusters, the approach generates independent cluster submodels, then, allowing parallel computation for obtaining lower bounds to the optimal solution value as well as feasible solutions for the problem up to optimality. We present a variation of the so named Branch-and-Fix Coordination exact algorithm that uses the splitting variable representation with explicit NAC for linking the submodels together, and a compact representation for each submodel to treat the implicit NAC related to each of the scenario clusters. The algorithm that is proposed uses the Twin Node Family (TNF) concept. It is specially designed for coordinating and reinforcing the branching nodes and the branching 0-1 variable selection strategies at each Branch-and-Fix (BF) tree, such that the symmetric scenario tree will be partitioned into smaller scenario cluster subtrees. The new approach does not intentionally explore all the problems ramifications, so it can not guarantee the optimality of the solution but the quasi-optimality gap of the incumbent solution is reasonably small, being obtained in an astonishing small computing time in the very provisional instances that we have experimented with.

Keywords: Multistage stochastic mixed 0-1 optimization, symmetric scenario trees, location facilities – demand splitting assignment, Branch-and-Fix Coordination metaheuristic.

Flexible Hub Location Problems with Capacity Constraints

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Abstract. The Single-Allocation Ordered Median Hub Location problem is a recent hub model introduced in [6] that provides an unifying analysis of the class of hub location models. In this work, we deal with the capacitated version of this problem. We present two formulation for this problem as well as some preprocessing phases for fixing variables. In addition, a strengthening of this formulation is also studied through the use of some families of valid inequalities. A battery of test problems with data taken from the AP library are solved where it is shown that the running times have been significantly reduced with the improvements presented in the paper.

Keywords: hub location problem, capacities, ordered median function

1 Introduction

The importance of hub location models in the area of Supply Chain networks is shown by the number of references published in the last years using different criteria to locate hubs, as for instance, minimizing the overall transportation cost (sum) among others), the largest transportation cost or the coverage cost; see the survey [1] and the references therein.

An interesting version of the hub location models is the Capacitated Hub Location Problem with Single Allocation. These models incorporate capacity constraints on the incoming flow at the hubs coming from non-hub nodes or even simpler, on the number of non-hub nodes assigned to each hub. It is worth mentioning that the capacity constraints make these models more realistic because in a large number of actual applications the hubs have not an unlimited capacity. In addition the inclusion of capacity constraints make these models challenging from a theoretical point of view. Regarding the applicability of these models we cite one example described in Ernst at al. [3] based on a postal delivery application, where a set of n postal districts (corresponding to postcode districts represented by nodes) exchange daily mail. The mail between all the pairs of nodes, must be routed via one or at most two mail consolidation centers (hubs). In order to meet time constraints, only a limited amount of mail could be sorted at each sorting center. Hence, there are capacity restrictions on incoming mail that must be sorted. The problem requires to choose the number and location of hubs, as well as to determine the distribution pattern of the mail.

The Capacitated Hub Location Problem with Single Allocation has received less attention in the literature than its uncapacitated counterpart. Campbell [2] presented the first integer Mathematical Programming formulation for the Capacitated Hub Location Problem. A new formulation using only two indices was proposed by Labbé et al. [5], where a polyhedral analysis and new valid inequalities were addressed. This formulation has only a quadratic number of variables but an exponential number of constraints.

Recently, the Single Ordered Median hub location problem, introduced by [6], has been recognized as a powerful tool from a modeling point of view. The reason being that this model allows to distinguish the roles played by the different parties in a hub-type supply chain network inducing new type of distribution patterns, see [4]. This formulation incorporates flexibility through rank dependent compensation factors, and it allows one to model that the driving force in the supply chain is shared by the suppliers and the distribution system. In this model, the objective is to minimize the total transportation cost of the flows between each origin-destination pair, routed through at most two hubs, once we have applied rank dependent compensation factors on the transportation costs of the origin-first hub links, and fixed scaling factors for the interhub and hub-final destination transportation costs. Therefore, deliveries from the origin sites to the distribution system are scaled by rank dependent weights. This adds a "sorting"-problem to the underlying hub location problem, making its formulation and solution much more challenging.

In this paper, we analyze in depth the above discussed model trying to obtain a better knowledge and alternative ways to solve it. More precisely, we will provide, first, a new formulation where the number of variables has been considerably reduced with respect to the one in [6]; second, several procedures for fixing variables that allow us to reduce the dimension of the problem and third, several families of valid inequalities for strengthening the formulation.

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A Stochastic Mixed 0-1 Formulation for the Capacitated Branch Restructuring Model

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During restructuring processes, due to mergers and acquisitions, banks frequently face the problem of having redundant branches competing in the same market. In an earlier work, we introduced a new Capacitated Branch Restructuring Model (CBRM) which extended the available literature in the location models. It considered both, closing down and long term operations costs, and addressed the problem of resizing open branches in order to maintain a constant service level. The model was tested in a simulated scenario and applied to a real life case, obtaining a reduction of about 38% of the network size, and yearly savings over 45% in operation costs.

In this work we introduce an extension to the CBRM, considering the more realistic case where the demand is not completely known. Alternatively, a set of scenarios that represent possible reactions of the customers to the restructuring is at hand. The result is a 0-1 mixed integer, stochastic programming model. We compare the solution offered by the deterministic model (where the available information about the uncertain parameters is replaced with its expected value) with the solution offered by our stochastic approach. Additionally, we compare the performance of a risk neutral restructuring strategy (i.e., minimizing the expected cost of restructuring) against two more sophisticated risk averse strategies based on first and second-order stochastic dominance constraints, mixed integer linear recourse measures.

Addressing the spatial nonstationarity in the Huff model parameters using Geographically Weighted Regression

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Abstract. In this paper a Multiplicative Competitive Interactive Model (MCI) is treated. Although several paper have addressed this type of model, including different ways for estimating the parameters involved, a very few documents have faced the spatial nonstationarity problem that may arise. Nakanishi and Cooper (1974) proposed one of the most used procedure for estimating the MCI parameters. They suggested some transformation in order to estimate the parameters by means ordinary least squares (OLS). This method does not take into account the possible spatial variation of the parameters because they are constant along the working space. Therefore, in order to consider the spatial nonstationarity we propose the use Geographically Weighted Regression (a local lineal regression method) instead the global ordinary least square. An application revealing the spatial nonstationarity of the OLS parameters is presented. This example is also used to show how the local regression model predicts data better than the OLS model.

Keywords. Multiplicative Competitive Interaction Model (MCI), nonstationarity, Geographycally Weighted Regression (GWR), competitive location

1 Introduction

The location of retail sites and their implications on the consumers' behavior has been studied in different areas; marketing, urban sciences, geomarketing, and so on. Different location models and procedures for calculating trading areas have been proposed in the specialized literature. The gravity models has widely used within the field of the retail distribution. These models are based on the assumption that individual movements between points are inversely proportional to the distance between them. The first gravity models were proposed by Reilly (1931) and Converse (1949) for estimating trading areas. Later, Huff (1964) proposed an alternative model where the attraction perceived by a customer from a facility is inversely proportional to the distance between them and directly proportional the facility size. According to this new model, the probability that a customer at *i* buys at a facility *j* is given by

$$p_{ij}=\frac{\dfrac{S_j^{\alpha}}{d_{ij}^{\lambda}}}{\sum_{j=1}^{n}\dfrac{S_k^{\alpha}}{d_{ij}^{\lambda}}} \tag{1}$$

where S_j represents the size of the facility *j*, *n* is the number of facilities operating in the market, d_{ij} is the distance (or travel time) from demand point *i* to facility *j*, and α and λ are parameters which reflect the effect of facility size and distance on consumer behavior and whose values are estimated empirically.

Nakanishi and Cooper (1974) proposed the following log-transformed-centered form to obtain ordinary least squares estimates of the parameters:

$$\ln\left(p_{ij}/\tilde{p}_{i\bullet}\right)=\alpha\ln\left(S_j/\tilde{S}_{\bullet}\right)+\lambda\ln\left(d_{ij}/\tilde{d}_{i\bullet}\right), \tag{2}$$

where $\tilde{p}_{i\bullet}, \tilde{S}_{\bullet}, \tilde{d}_{i\bullet}$ are the geometric means of p_{ij}, S_j, d_{ij}, respectively.

Parameters obtained from (2) are influenced by socio-demographic characteristics of the market. Local difference in this aspect (changes in density population or income ratios) may produce local difference in customers' perceptions of the facilities attraction. Different alternative has been proposed in order to consider this spatial nonstationarity (see, for example Gosh (1984)). In this paper, we propose solving model (2) by means local lineal regression, in particular using Geographically Weighted Regression (GWR). This technique estimates one couple of parameters α and λ for each element of the sample, showing their variability along the study space. See Fotheringham et al. (2002) for a complete summarization of this technique.

GWR can also be used for estimating a pair of parameters α_i and λ_i for each demand point *i* and then calculate the local probabilities p_{ij} by changing α and λ for the local estimations.

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Multicriteria flow models for disaster relief operations

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Abstract. Natural and human-made disasters cause humanitarian crises all around the world. Relief organizations respond in different ways and Humanitarian Logistics are a key factor to achieve effectiveness, efficiency and transparency. Mathematical models specifically designed for this kind of logistics can help to make strategic and tactical decisions in this context, when decisions must be taken in a multicriteria environment. In this work a multicriteria dynamic flow model for aid distribution operations is developed and compared with its static version.

Keywords: Humanitarian Logistics, Distribution models, Multicriteria Decision Making, Flow Models

Natural and human-made disasters cause humanitarian crises all around the world. When help is requested from international instances, due to the intensity of the phenomenon or to the vulnerability of the country, relief organizations respond in different ways, and Humanitarian Logistics play an important role. In Ref. [1] an up-to-date review of decision aid models in emergency logistics can give an idea of the last developments in the field. Focusing only on optimizations models, Ref. [2] provides a very complete review.

This work deals with last-mile distribution in disaster relief operations. In particular, the problem addressed consists of designing routes for vehicles among nodes that have an available quantity of goods or a demand of those goods. The most appropriate types of vehicles to be used and the flow of aid through the network must be determined. More specifically, the problem addressed is described through the following elements:

1. Transportation Network. Nodes representing the places of pick-up, delivery or connection, and main links characterized by distance, average velocity and reliability.
2. Goods. Information about the amount of aid available or required at each node.
3. Vehicles. Several types are considered, characterized by capacity, average velocity, variable and fixed costs and availability in each node of the network.

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4. Operation elements: They include the global quantity of aid to be distributed in the operation and the budget available.

The problem consists of designing the load and vehicles flow through the network so that a fixed amount of humanitarian aid is distributed under some budget constraints.

The optimization process can be guided by different criteria. It has been recognized in the last times that traditional logistic objectives, such as minimizing operations cost, are not the most relevant in humanitarian operations. On the contrary, other criteria such as time of operation or equity in the distribution, must take a prominent role. In Ref. [3] a goal programming static flow model is presented to deal with this problem, which provides an approximation to the best distribution plan using up to six conflicting criteria. Nevertheless, the static flow model provides an operation planning and gives an idea about the resources needed and the values of the considered criteria, but it doesn't provide a realistic scheduling, since only one arrival or departure time point is defined for each node.

In this work a dynamic flow model that extends the previous static one is proposed. This dynamic model provides a more detailed scheduling, as it considers explicitly the movement of vehicles in the different periods of time, allowing arrivals and departures from the same node at different times.

The model includes several criteria, as the multicriteria nature of the problem demands, and deals with them through a lexicographical goal programming scheme, as it was done in the static model. The first level is focused on distributing the amount of goods proposed into the operation (effectiveness), assuming that there is not trade-off between this criterion and other performance ones. In the second level the criteria considered are operation time, equity, reliability and cost. These criteria are desired to be fitted to some targets and are aggregated using weighted goal programming.

Computational experience is presented to compare both models on a case study based on the Haiti earthquake 2010. The solutions provided by both models for one of the instances are shown, in order to understand the differences between the solutions given by each model.

As a result of this experience, a methodology based on the coordination of the two models is proposed, in order to improve the efficiency of the solution method.

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