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INTERNATIONAL WORKSHOP ON

LOCATIONAL ANALYSIS AND RELATED PROBLEMS

SEVILLE, SPAIN

OCTOBER 1-3, 2014

This conference is partially supported by the Spanish Government, grant **MTM2010-12053-E**.

Contents

Preface

The ***International Workshop on Locational Analysis and Related Problems 2014*** is organized by the **Spanish Location Network and Grupo Español de Localización (GELOCA).** The Spanish Location Network is a group of more than 140 researchers, with members from 21 Spanish universities. The Network appeared in 2002 being financed by the Spanish Government (grant FM2002-10418-E, MTM2004-22566-E, MTM2005-24550-E y MTM2006-27490-E, MTM2007-30163-E, MTM2008-02221-E y MTM2009-07290-E, MTM2010-12053-E). The origin of the Network is connected to the *Grupo Español de Localización* (GELOCA) which is one of the groups integrated in the Spanish Society of Statistics and Operations Research.

Every year, the Network organizes a meeting to promote the communication between its members and between them and other researches, and to contribute to the development of the location field and related problems. The last workshop took place in Malaga, June 19-21, 2013. This year, the meeting takes place in Seville. 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.

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

The organizing committee.

Committees

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General Information

Place

The meeting will take place in *Instituto de Matemáticas (IMUS). Universidad de Sevilla*. C/ Tarfia S/N. 41012 Sevilla. http://www.imus.us.es/

Information for speakers

The total time allocated to each speaker is 25 minutes, including time for questions and audience participation.

Lunches

Lunches will be held at *Comedor Universitario de la Facultad de Matemáticas,* Universidad de Sevilla.

Timetable

WEDNESDAY 1	
18:00-18:30	Registration
18:30-19:00	Opening Session
19:00	Welcome Reception
THURSDAY 2	
9:00-11:05	Session 1
11:05-11:35	Coffe Break
11:35-12:35	Invited speaker: Martine Labbé Network design problems in phylogenetics
12:35-13:35	Invited speaker: Andrea Scozzari Partitioning a graph into connected components with fixed centers and optimizing different criteria
13:35-15:05	Lunch
15:05-17:10	Session 2
17:10-17:30	Break
17:30-18:45	Session 3
20:00	Dinner
Permanent exhibition of posters	
FRIDAY 3	
9:00-11:05	Session 4
11:05-11:35	Coffe Break
11:35-12:35	Invited speaker: Gerhard Reinelt Ordering problems
12:35-13:30	Reunión de la Red de Localización
13:30-15:00	Lunch
15:00-16:40	Session 5
16:40	Closing Session
Permanent exhibition of posters	

Program

Wednesday 1

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

Thursday 2 (morning)

09:00-11:05 **Session 1**
Chair: Enrique Domínguez

The permutated asymetric traveling salesman problem
Javier Alcaraz, Eva M. García-Nové, **Mercedes Landete**, Juan F. Monge, Justo Puerto

The p-median facility location problem with uncertainty on the cost
Sergio García, Laureano Escudero

Scatter Search for an uncapacitated p-hub median problem
Rafael Martí, Ángel Corberán, **Juanjo Peiró**

Capacitated ordered median location problems
Justo Puerto, Antonio M. Rodríguez-Chía, **María del Carmen Sánchez-Gil**

Discrete ordered median problem induced order
Enrique Domínguez, Alfredo Marín

11:05-11:35 **Break**

11:35-12:35 **Invited speaker: Martine Labbé**
Network design problems in phylogenetics

12:35-13:35 **Invited speaker: Andrea Scozzari**
Partitioning a graph into connected components with fixed centers and optimizing different criteria

13:35-15:05 **Lunch**

Thursday 2 (afternoon)

15:05-17:10 Session 2
Chair: Ángel Marín

Railway rapid transit network timetabling with shared segments
David Canca, Eva Barrena, Alicia de los Santos, Juan A. Mesa

Location of rest facilities in rapid railway transit networks: Design and operation decisions
David Canca, Eva Barrena, Francisco A. Ortega

Selecting the stations and links for a rapid transit network from the results of a survey
Laureano F. Escudero, Susana Muñoz

Integrated robust airline scheduling under stochastic demand
Luis Cadarso, Ángel Marín, Bernard Gendron

Solving methods for crew scheduling problem in rapid transit networks
Manuel Fuentes, Ángel Marín

17:10-17:30 Break

17:30-18:45 Session 3
Chair: Diego Ruiz-Hernández

The variable selection problem for clustering: An integer linear programming approach
Stefano Benati, Sergio García Quiles, Justo Puerto

Location of hydrogen refueling sations: An equilibrium approach
Eusebio Angulo Sánchez-Herrera, **Carlos Funes** Guerra, Ricardo García-Rodenas, Doroteo Verastegui Rayo

Cournot-Stackelberg games in competitive delocation
Diego Ruiz-Hernández, Javier Elizalde-Blasco

Friday 3 (morning)

9:00-11:05 **Session 4**
Chair: Victor Blanco

On the existence of Nash equilibria in location games
María de las Mercedes Pelegrín García, Blas Pelegrín Pelegrín

Tabu search and GRASP for the capacitated clustering problem
Anna Martínez Gavara, Vicente Campos, Micael Gallego, Manuel Laguna, Rafael Martí

On covering location problems on networks with edge demand
Oded Berman, **Jörg Kalcsics**, Dmitry Krass

An exact approach for solving uncapacitated facility location models with concave operating costs
Robert Aboolian, Emilio Carrizosa, **Vanesa Guerrero**

On continuous location with region-dependent l_p distances
Victor Blanco, Justo Puerto, Diego Ponce

11:05-11:35 **Break**

11:35-12:35 **Invited speaker: Gerhard Reinelt**
Ordering problems

12:35-13:30 **Reunión de la Red de Localización**

13:30-15:00 **Lunch**

Friday 3 (afternoon)

15:00-16:40 Session 5
Chair: Ángel Corberán

Optimizing the design of solar power tower systems with multiple receiver
Emilio Carrizosa, **Carmen A. Domínguez-Bravo**, E. Fernández-Cara, M. Quero

An evolutionary algorithm based on a new encoding for a two-stage location transportation problem
Herminia I. Calvete, **Carmen Galé,** José A. Iranzo

Analysis of different formulations for the distance-constrained generalized directed rural postman problem
Thais Ávila, Ángel Corberán, Isaac Plana, **José M. Sanchis**

On the generalized directed rural postman problem
Thais Ávila, Ángel Corberán, Isaac Plana, José M. Sanchis

16:40 Closing session

Posters

Juan A. Mesa, Francisco A. Ortega, Miguel A. Pozo
Using expected distances along the network for designing irrigation networks by using a p-median model

Dolores R. Santos-Peñate, Clara Campos-Rodríguez, José A. Moreno-Pérez
The generalized discrete (r|p)-centroid problem

Abstracts

Invited Speakers

NETWORK DESIGN PROBLEMS IN PHYLOGENETICS

Martine Labbé

Université Libre de Bruxelles, Belgium

A phylogeny is an unrooted (generally binary) tree that represents the evolutionary relationships of a set of *n* species. Phylogenies find applications in several scientific areas ranging from medical research, to drug discovery, epidemiology, systematics, and population dynamics. In such applications, the available information is usually restricted to the leaves of a phylogeny and is represented by molecular data extracted from the analyzed species, such as DNA, RNA, amino acid, or codon fragments. The phylogeny can be determined by solving a network design problem, called the phylogeny estimation problem (PEP) which consists in determining a tree whose leaves are the species under study. Several versions of the problem exist depending on the criterion used to select a phylogeny from among plausible alternatives. This talk presents an overview of several such network design problems as well as recent results concerning them.

ORDERING PROBLEMS

Gerhard Reinelt

University of Heidelberg, Germany

Manifold combinatorial optimization problems are concerned with the determination of optimal orderings of objects subject to various types of constraints and objectives. In particular, the objective function has a big influence on the difficulty of an ordering problem and on suitable optimization algorithms. In this talk we survey some of these problems and report about approaches for solving them to optimality. Special focus will be given to the target visitation problem which is a combination of the linear ordering problem and the traveling salesman problem.

Partitioning a graph into connected components with fixed centers and optimizing different criteria

Andrea Scozzari

Universita' degli Studi Niccolo' Cusano, Roma, Italy

We consider a connected graph G with n vertices, p of which are centers, while the remaining ones are units. For each unit-center pair there is a fixed assigning cost and for each vertex (both units and centers) there is a non negative weight. In this paper we study the problem of partitioning G into p connected components such that each component contains only one center (p-centered partition). We analyze different optimization problems of this type by defining different objective functions based on the assigning costs, or on the vertices' weights, or on both of them. For these problems we show that they are NP-hard on very special classes of graphs, and for some of them we provide polynomial time algorithms when G is a tree.

Sessions

(In alphabetical order of the first author)

AN EXACT APPROACH FOR SOLVING UNCAPACITATED FACILITY LOCATION MODELS WITH CONCAVE OPERATING COSTS

Robert Aboolian[1], Emilio Carrizosa[2], and Vanesa Guerrero[2]

[1]College of Business Administration, California State University San Marcos.
[2]Instituto de Matemáaticas de la Universidad de Sevilla

We consider a nonlinear version of the Uncapacitated Facility Location Problem (UFLP). The total cost, to be minimized, has two parts: the transportation costs, supposed to be linear in the (client,plant) allocations, and the operation costs, which are here assumed to be given by a concave nondecreasing function of the demand served by each open facility. Thus we call the problem Uncapacitated Facility Location Problem with Concave Operating Cost (UFLPCOC). The problem is modeled and an exact solution approach is presented. This approach is mainly based on obtaining efficient lower and upper bounds for UFLPCOC. Lower bounds are obtained by solving a UFLP with extra linear constraints. To find an upper bound, we present a heuristic which is based on a neighborhood search over the location set from the solution to the previous Mixed Integer Linear Program. The exact approach is based on successive lower and upper bound improvements for UFLPCOC until convergence is obtained. Computational results are presented.

THE PERMUTATED ASYMMETRIC TRAVELING SALESMAN PROBLEM

Javier Alcaraz[1], Eva M. García-Nové[1], Mercedes Landete[1], Juan F. Monge[1], and Justo Puerto[2]

[1]Departamento de Estadística, Matemáticas e Informática, Centro de Investigación Operativa, Universidad Miguel Hernández de Elche, Spain
[2]IMUS. Universidad de Sevilla, Spain.

We consider that solutions to the Asymmetric Traveling Salesman Problem (ATSP) might go into the wrong order with certain probabilities and we look for robust solutions (tours) for the Asymmetric Traveling Salesman Problem against permutations. Our goal is to analyze this new robust variant of the ATSP and to look for the solution which minimizes the expected route cost. We provide several models for the problem, analyze them by means of a computational study and also study several of its intrinsic properties.

Keywords: Asymmetric Traveling Salesman Problem, Integer Programming, Quadratic Assignment Problem.

LOCATION OF HYDROGEN REFUELING STATIONS: AN EQUILIBRIUM APPROACH

Eusebio Angulo Sánchez-Herrera[1], Carlos Funez Guerra[2,3], Ricardo García-Ródenas[1] and Doroteo Verastegui Rayo[3]

[1]Departamento de Matemáticas, Escuela Superior de Informática. Universidad de Castilla la Mancha. 13071. Ciudad Real, Spain.
[2]Centro Nacional del Hidrógeno, Prolongación Fernando el Santo s/n. 13500, Puertollano, Spain.
[3]Escuela de Ingeniería Minera e Industrial de Almadén, Plaza Manuel Meca s/n. 13400, Almaden, Spain

The use of Alternative fuel vehicles (AFV) in general, and of those based on hydrogen fed fuel cells (Fuel cell vehicles – FCV), in particular, to replace vehicles powered by internal combustion, is an alternative form of road transport that may provide, in the long term, security in energy supply, reduction in greenhouse gas emissions and improvement in air quality in cities.

There are five areas which should be addressed in order to guarantee market penetration of environmentally friendly cars: (a) the purchase price, (b) running costs, (c) vehicle range before refueling, (d) refueling time and (e) availability of refueling stations.

Location models are intended to accelerate market penetration of these vehicles, making efficient decisions about infrastructure design.

In this work, we describe a bilevel model for the optimum definition of subsidy policies for the promotion of hydrogen infrastructure. The model includes the behavior of hydrogen station owners in a competitive environment, modeling of user behavior (buying of Fuel Cell Vehicles, choice of trips, routes), station coverage and incentivization policies, determining the optimum policy which allows a certain level of coverage to be achieved by a network in a given year.

A model is described which allows, by Stackelberg equilibrium, a "road map" to be modeled for the optimal development of future infrastructure of hydrogen filling stations, so as to achieve the set objectives with minimum consumption of public resources.

On the Generalized Directed Rural Postman Problem

Thais Ávila[1], Ángel Corberán[1], Isaac Plana[2], José M. Sanchis[3]

[1]Dept. d'Estadística i Investigació Operativa, Universitat de València, Spain
[2]Dept. de Matemáticas para la Economía y la Empresa, Universitat de València, Spain
[3]Dept. de Matemática Aplicada, Universidad Politécnica de Valencia, Spain

The Generalized Directed Rural Postman Problem (GDRPP), also known as the Close-Enough Arc Routing Problem, is an arc routing problem with some interesting real-life applications, such as routing for meter reading. In this application, a vehicle with a receiver travels through a series of neighborhoods. If the vehicle gets closer than a certain distance to a meter (customer), the receiver is able to record the gas, water, or electricity consumption. Therefore, the vehicle does not need to traverse every street, but only a few, in order to get close enough to each meter. Note that in most arc routing problems each customer must be serviced from exactly one street, and thus the goal is to find a route traversing all the streets in a given set. However, in the GDRPP each customer can be serviced from one or more streets, so the vehicle only needs to traverse one of them. In this talk we introduce two new formulations for this problem as well as various families of new valid inequalities that are used to design and implement a branch-and-cut algorithm. The computational results obtained on test bed instances from the literature show that this algorithm outperforms the existing exact methods.

References

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ANALYSIS OF DIFFERENT FORMULATIONS FOR THE DISTANCE-CONSTRAINED GENERALIZED DIRECTED RURAL POSTMAN PROBLEM

Thais Ávila[1], Ángel Corberán[1], Isaac Plana[1] and José M. Sanchis[2]

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The Generalized Directed Rural Postman Problem (GDRPP) is an arc routing problem with some interesting real-life applications, such as routing for meter reading. In this problem, we have a family of arc subsets and the goal is to find a minimal cost tour traversing an arc in each subset. The Distance-Constrained GDRPP is a generalization of this problem in which a fleet of identical vehicles is available and the goal is to minimize the sum of the costs of all the routes, provided that no route exceeds a maximum distance. In this talk we introduce and compare several formulations for this problem. Moreover, different families of valid inequalities are proposed. Some results with preliminary branch-and-cut algorithms are reported.

Keywords: Multi-vehicle arc routing problem, Generalized Rural Postman Problem, Close-Enough Arc Routing Problem, branch-and-cut

THE VARIABLE SELECTION PROBLEM FOR CLUSTERING: AN INTEGER LINEAR PROGRAMMING APPROACH

Stefano Benati[1], Sergio Garcia Quiles[2] and Justo Puerto[3]

[1]School of International Studies, University of Trento, Italy.
[2] School of Mathematics, University of Edinburgh
[3] Faculty of Mathematics, University of Sevilla, Spain

Finding structure in high-dimensional data is a difficult task that is even harder if data contains variables with no relevant information. If those variables are not detected and discarded form the analysis, the sequent analysis can be blurred or biased by their presence. The problem becomes more and more important as the number of variables increases: Nowadays standard data base can comprise hundredths and even thousands of covariates, and therefore researchers from different disciplines need tools to detect and discard what are called noisy or masking variables.

There are three ways to address the problem of the masking variables. The most simple relies on peculiar indexes to detect variables that do not show evident patterns. The methodology begins with applying a form of standardization to data, calculate a clusterability index, add variables to data set in a greedy fashion, finally apply a clustering algorithm like *k*-means to the reduced data set. Conversely, the most sophisticated methodology assumes a multivariate probability distributions, whose parameters must be estimated through applications of the EM algorithm. One EM iteration complexity is at most quadratic, and numerical stability is an issue, therefore there are applications in which this methodology is unreliable.

As the third way, some authors proposed a mathematical programming approach to detect masking variables. Here we present our new methodology, which is based on the formulation of the problem as Integer Linear Programming. We formulate the problem of the variable selection as follows: A set $U = \{1, \ldots, n\}$ of statistics units and a set $R = \{1, \ldots, r\}$ of cluster centers, or prototypes, are given. For every $i \in U$ and every $j \in R$, a set $V = \{1, \ldots, m\}$ of statistics variables are measured, so that the for every triple $i \in U$, $j \in R$, $k \in V$, a distance d_{ijk} is calculated, that is the difference measured through variable k between the statistic unit i and the cluster center j. If a subset $Q \subset V$ of variables is selected, the i, j distance using Q is the sum: $d_{ij}(Q) = \sum_{k \in Q} d_{ijk}$. Distances Q are used to determine the partition of U into clusters G_j , $j = 1, \ldots, r$: For a fixed $Q \subseteq V$, a unit i is assigned to cluster $j(i)$ if $d_{i,j(i)}(Q) = \min\{d_{ij}(Q) \mid j = 1, \ldots, r\}$. The total distance between units and clusters is the sum: $D(Q) = \sum_i d_{i,j(i)}(Q)$. The Variable Selection Problem is to select the subset $Q \subseteq V$ for which the objective function $D(Q)$ is minimized.

We show that the problem is NP-hard, but we found two Integer Linear Programming formulations that allow the application of standard software as Cplex or LpSolve to its solution, and the two formulations are compared in term of time and quality of their linear relaxation. We developed two heuristic algorithms that are based on the ILP

formulations, that resemble to two approaches to p-median problem, one is the selection-allocation heuristic, one is the add-swap interchange heuristic. Again, both are compared in term of time and solution quality. The main feature of a possible Lagrangian relaxation heuristic will also be sketched. Finally, we show how the model can be plugged-in to classic clustering algorithms like the k-mean, the p-median, or to EM model-based clustering to reduce the data dimension and improve the quality of the clustering. Finally, we show how the model can be applied to data coming from the World Value Survey.

ON COVERING LOCATION PROBLEMS ON NETWORKS WITH EDGE DEMAND

Oded Berman[1], Jörg Kalcsics[2], Dmitry Krass[1]

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We discuss two covering location problems on a network where the demand is distributed along the edges. The first is the classical maximal covering location problem and the second is the obnoxious version where the coverage should be minimized subject to some distance constraints between the facilities. The demand distribution along each edge is given as a non-negative continuous function and we assume that its antiderivative is known.

Starting with the single facility problem, we first show that the finite dominating set for the node covering problem does not carry over to the case of edge demands. Afterwards, we present a solution approach for arbitrary demand functions and discuss some special cases. Next, we focus on the multi-facility problem under the assumption that the demand is constant on each edge. We present several discretization results for tree networks and show that these results do not carry over to general networks.

Keywords: Network location, covering, continuous demand, trees, finite dominating sets.

ON CONTINUOUS LOCATION WITH REGION-DEPENDENT l_p DISTANCES

Victor Blanco[1], Justo Puerto[2] and Diego Ponce[2]

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[2] Dpt. Statistics & OR, Universidad de Sevilla

In this paper we address the problem of locating a new facility on a d-dimensional space when the distance measure (l_p- or polyhedral-norms) is different at each one of the sides of a given hyperplane H. We relate this problem with the physical phenomenon of refraction, and extends it to any finite dimension space and different distances at each one of the sides of any hyperplane. An application to this problem is the location of a facility within or outside an urban area where different distance measures must be used. We provide a new second order cone programming formulation, based on the l_p-norm representation given by Blanco et. al (2013) that allows to solve, exactly, the problem in any finite dimension space with semidefinite programming tools. We also extend the problem to the case where the hyperplane is considered as a rapid transit media (a different third norm is also considered over H) that allows the demand to travel faster through H to reach the new facility. Extensive computational experiments run in Gurobi are reported in order to show the effectiveness of the approach.

INTEGRATED ROBUST AIRLINE SCHEDULING UNDER STOCHASTIC DEMAND*

Luis Cadarso[1], Ángel Marín[2], Bernard Gendron[3]

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This paper looks at the airline-scheduling problem and develops an integrated approach that optimizes schedule design, fleet assignment and passenger use so as to reduce costs and create fewer incompatibilities between decisions. As passenger demand is characterized by uncertainty, we introduce stochastic variations caused by daily passenger demands in actual operations. To consider such stochastic disturbances we develop a stochastic-demand scheduling model where robust itineraries are introduced to ameliorate misconnected passengers. This integration leads to a huge model difficult to solve: an improved and accelerated Benders decomposition is proposed. The analytical work is supported with a case study involving the Spanish airline, IBERIA. Our approach shows that the number of misconnected passengers can be reduced when robust planning is applied.

Key words: Schedule design, fleet assignment, stochastic demand, robustness.

***** This research was supported by project grant TRA2011-27791-C03-01 by the 'Ministerio de Economía y Competitividad, Spain'.

AN EVOLUTIONARY ALGORITHM BASED ON A NEW ENCODING FOR A TWO-STAGE LOCATION TRANSPORTATION PROBLEM

Herminia I. Calvete, Carmen Galé and José A. Iranzo

Universidad de Zaragoza

The two-stage location transportation problem addressed in this work consists of selecting a subset of locations from a set of potential depots in order to deliver a commodity from a set of plants to a set of customers with known demand using the depots as intermediate transshipment points. The aim is to minimize overall costs. These costs refer to fixed costs due to using the selected depots and to variable shipping costs. We propose a hybrid evolutionary algorithm to solve the problem. The new chromosome encoding controls the depots which are open. The use of optimization techniques allows the algorithm to associate a good feasible solution to each chromosome. The computational results show the efficiency of the algorithm in terms of the quality of the solutions yielded and the computing time.

RAILWAY RAPID TRANSIT NETWORK TIMETABLING WITH SHARED SEGMENTS

David Canca[1], Eva Barrena[2], Alicia de los Santos[3], Juan A. Mesa[3]

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Railway timetables design has been treated in the scientific literature under two main approaches, periodic and non-periodic timetabling. In case of periodic timetables, the usual objective is obtaining a schedule as similar as possible to an ideal one, previously proposed by railway operators. On the other hand, non-periodic timetables are usually designed following users and operator preferences, considering operating costs or travel and waiting times.

In this paper we propose a new optimization model to compute network regular timetables in case of rapid railway systems taking into account shared segments with multiple lines and tracks, where lines have to be allocated to tracks. The model considers passenger demand in form of an origin destination matrix and solve the network loading problem whereas determining optimal frequencies and lines allocation in shared segments. In order to obtain practical solutions, a set of new constraints affecting frequencies have to be imposed in segments supporting several lines. Discussions about simultaneously determining optimal capacity are also considered. Finally, the proposed model is applied to a real RRT network.

LOCATION OF REST FACILITIES IN RAPID RAILWAY TRANSIT NETWORKS: DESIGN AND OPERATION DECISIONS

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Rolling stock circulation consists on the determination of train routing and services allocation accordingly to a pre-defined train schedule. Rolling stock is a very important stage in tactical planning for railway transportation companies. The rolling stock plan should define individual train paths over the network with the objective of minimizing costs. Moreover, maintenance of train units must be also considered.

In this paper we consider, in the context of RRT systems, a methodology based on the sequential resolution of two mixed integer programming models in order to develop rotating rolling stock circulation and maintenance plans. This approach give raise to a long term impact analysis of rest facilities location under two different perspectives. By one side, at a design stage, determining the location and optimal number of rest facilities. By other side, at an operation stage, considering new facilities' location as well as reallocation decisions.

The proposed approach is finally illustrated in case of a medium size RRT network.

OPTIMIZING THE DESIGN OF SOLAR POWER TOWER SYSTEMS WITH MULTIPLE RECEIVER

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We present a Solar Power Tower system with multiple receiver technology emphasizing the system optimization procedure. The optimization of the heliostat field and the receivers are addressed, involving the receivers heights, dimensions, inclinations and angular positions. A new method is developed in order to solve this new problem, based on an alternating greedy-based heuristic method, already used to design a Solar Power Tower system with one receiver.

Maximizing the energy generated per unit cost, leads to a difficult high dimensional global optimization problem with an objective function hard to compute and nonconvex constraints as well. The problem is reduced to two sub-problems, mainly the heliostats location problem and the tower-receivers design problem. These sub-problems are strongly dependant that is the reason to apply the alternating procedure.

Regarding the heliostats location problem, when using multiple receiver technology, some difficulties appear. For each receiver, different feasible regions where the heliostats will be placed have to be considered, called sub-fields. These regions are determined by the algorithm for each receivers configuration. Moreover, the shadow-blockage calculation becomes more complicated, due to the different heliostat tilts that appear when near heliostats focus on different receivers. Therefore, the behavior of the shadow-blockage effects in the boundaries of the sub-fields has to be carefully model in order to obtain a realistic solution. Note that, the common use of geometric patterns to solve this location problem can not be applied directly due to the already mentioned difficulties.

It is also worth noting that in the tower-receivers design problem, the receivers are consider independent between them, as each receiver aim to a different sub-field, only the constraints to obtain a feasible solution have to be taken into account. The problem where the energy reached by one receiver is somehow related with the energy reached by the remaining ones can be also studied.

The main results are presented showing the viability of the alternating algorithm and the heliostat location problem with multiple receiver systems. In Figure 1, an example of the sub-field regions selection and the heliostats location for a given three receivers configuration, pointing to the North, East and West, can be seen.

Keywords: energy, solar thermal power, multiple receiver, global optimization, heuristics.

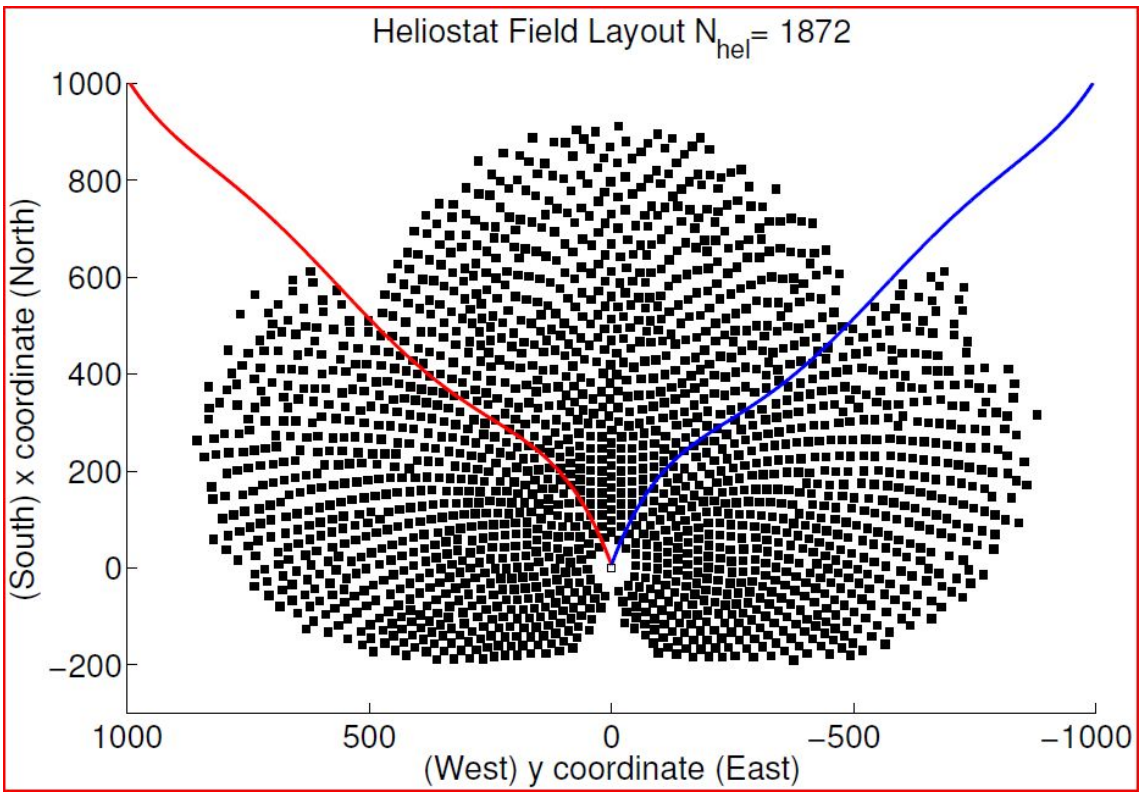

Figure 1: Multiple Receiver Field

DISCRETE ORDERED MEDIAN PROBLEM WITH INDUCED ORDER

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The discrete ordered median problem (DOMP) was introduced to provide a way to model many of the popular discrete location models. This was achieved introducing the order to the objective function and applying a set of penalties depending on this order. In this sense, the flexibility in the modelling is increased. A great number of algorithms has been developed to solve the DOMP. Both exact methods and heuristics have been successfully applied to solve the problem. Moreover, specialized formulations have been also introduced to solve optimally medium sized instances of DOMP.

In this work, a multi-facility version of DOMP is addressed. Concretely, in this case two kinds of facilities are considered. Therefore, the goal of the proposed DOMP with induced order (DOMP+IO) is to locate all the facilities in such a way that a client should not be far from a secondary facility if she is far from (near to) a primary facility. For instance, hospitals can be considered as primary facilities and heliports as secondary facilities. Consequently, the generalization of DOMP is carried out by introducing an induced order on the secondary facilities.

Preliminary results show that only small instances can be solved optimally in a reasonable computational time. In this work, a genetic algorithm is provided to attack larger instances of DOMP+IO.

SELECTING THE STATIONS AND LINKS FOR A RAPID TRANSIT NETWORK FROM THE RESULTS OF A SURVEY

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In this work we present an integer linear programming model for selecting the stations and links to be constructed for a rapid transit network. It maximizes an estimation of the number of trips through the rapid transit network. Instead of considering a static origin-destination matrix, we compute the expected number of trips by making use of the results from a survey amongst the potential users of the rapid transit network. We also report some computational experiments on randomly generated instances.

SOLVING METHODS FOR CREW SCHEDULING PROBLEM IN RAPID TRANSIT NETWORKS

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The application of some different solving methods for a new approach to the Crew Scheduling Problem in Rapid Transit Networks is discussed. The considered problem formulation has a structure that take special advantage of an ad-hoc designed decomposition, and suggests taking into account methods such as Lagrangian Relaxation. Its implementation is intended to both improve the lower bound and speed up the solving process.

Keywords: Crew scheduling, Solving methods, Decomposition methods, Lagrangian relaxation

THE P-MEDIAN FACILITY LOCATION PROBLEM WITH UNCERTAINTY ON THE COSTS

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The p-median problem is one of the most classical problems in Discrete Location and consists on choosing p locations and assigning the other locations to these p medians so that total allocation cost be minimum. Here we study how to solve this problem when the costs are uncertain: a radius based formulation is developed to model the minimization of the expected cost over a set of scenarios at the same time that a set of first order stochastic dominance constraints are required to reduce the risk on the cost due to non-wanted scenarios. A computational study is provided.

SCATTER SEARCH FOR AN UNCAPACITATED P-HUB MEDIAN PROBLEM

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Scatter search is a population-based method that has been shown to yield promising outcomes for solving combinatorial optimization problems. It uses strategies for combining solution vectors that have proved effective in a variety of problem settings. In this paper, we present a scatter search implementation for an NP-hard variant of the classic p-hub median problem. Specifically, we tackle the uncapacitated r-allocation p-hub median problem, which is the problem consisting of minimizing the cost of transporting the traffics between nodes of a network through special facilities that act as transshipment points. This problem has a significant number of applications in practice, such as the design of transportation and telecommunications networks.

As it is customary in metaheuristic implementations, we design specific methods to create an efficient solving procedure based on this scatter search methodology. In particular, we propose mechanisms to generate, combine, and improve solutions for this problem. Special mention deserves the use of path-relinking as an extension of the classical combination method.

Extensive computational experiments establish the effectiveness of our procedure in relation to approaches previously identified to be best.

Keywords: scatter search, path-relinking, hub location, p-hub, r-allocation, combinatorial optimization.

TABU SEARCH AND GRASP FOR THE CAPACITATED CLUSTERING PROBLEM

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The Capacitated Clustering Problem (CCP) consists of forming a given number of clusters or groups from a set of elements in such a way that the sum of the weights of the elements in each cluster is within some capacity limits, and the sum of the benefits between the pairs of elements in the same cluster is maximized. This problem arises in the context of facility planners at mail processing and distribution, and a GRASP with VNS has been recently proposed (see Deng and Bard (2011)). In this paper we propose a tabu search and several GRASP for this NP-hard problem. They are based on different neighborhoods, including a new one, not previously proposed for the CCP, in which we implement a one-for-two swapping. We also hybridized both methodologies for improved outcomes.

The Maximally Diverse Grouping Problem (MDGP) is a particular case of the CCP in which all the elements have a weight of one unit (Gallego et al. (2013)). This problem has been recently studied in the academic context when forming student groups, and we adapt now its best method, a tabu search with strategic oscillation (TS_SO), to the CCP. Our empirical study with 50 large instances shows the superiority of the new GRASP with tabu search for the CCP with respect to both the previous GRASP with VNS and the adapted TS_SO.

References

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USING EXPECTED DISTANCES ALONG THE NETWORK FOR DESIGNING IRRIGATION NETWORKS BY USING A P-MEDIAN MODEL

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The increasing need to rationalize water resources in the agricultural sector has forced the introduction of new water distribution systems. The design and dimensioning of the network of pressurized water for irrigation has the following phases: Location of hydrants, Network Designing, Determination of circulating flows for each of the lines and Determination of pipe diameters.

Clearly the cost of pipes and hydrants between parcels depend on the location of fire hydrants and which parcels are assigned. The location - allocation approaches can help to find solutions that minimize this cost.

The p-Median Problem (Hakimi, 1964) is a common location-allocation model for finding p facility locations among a set of candidates so that the total access distance, required to serve a fixed demand, is minimized.

The p-median model aims at determining the location of a number of service centers (hydrants) and to assign each demand item (parcel) to a center such that total travel cost is minimized. In this paper a p-median location - allocation model is introduced by using a discrete version of expected distances.

Keywords: Irrigation planning, Water distribution systems, Location.

ON THE EXISTENCE OF NASH EQUILIBRIA IN LOCATION GAMES

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The concept of Nash equilibrium was developed by John F. Nash (1951) and has been applied to a range of fields linked to Game Theory. In location games, the players are firms that compete for the market with the aim of profit maximization. Once firms choose their facility locations, customers select a facility to be supplied. The profit a firm gets depends on the facility locations of the competing firms as well as some facility characteristics, such as price, quality, parking area, etc.

A variety of location games arise depending on the patronizing customer behaviour, location space, number of players, etc. If there is no cooperation among firms, a widely known solution of the game is the Nash equilibrium (NE). A NE is defined as a set of facility locations of the firms such that no firm can increase its profit by changing the location of its facilities while the facility locations of its competitors remain fixed.

In this paper we check the existence of Nash equilibria for location games where prices are involved and the location space is a plane or a network. There are different ways to show the existence of NE for a given game, e.g., finding a NE, using some property of that game, or applying some fix point theorem.

We firstly study the location games with mill pricing, finding a NE in very special cases and showing that there is no NE in other cases. Then location games with delivered pricing are considered. For these games a NE always exists if customer demand is fixed and does not depend on price. In this case, the existence of a NE is proven by using the relationship between the payoff function and the social cost, which leads to show that a social cost minimizer is NE. Since social cost is a continuous function in the location variables, a NE exists if the location candidates are compact sets in a plane. For a network, nodes which are minimizer of social cost exist.

Fix point theorems, which have been used to show the existence of NE in others types of games, fail when they are applied to show the existence of a NE in the above mentioned location games. In a plane, this is due to the lack of continuity of the payoff functions, or to the fact that the set of optimal locations for one firm, when the locations of its competitors are fixed, is not a convex set. However, we introduce a new class of location games with mill pricing, for which the existence of a NE is shown by applying the fix point Kakutani theorem.

Key words: Competitive location, Nash equilibrium.

CAPACITATED ORDERED MEDIAN LOCATION PROBLEMS

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Flexible discrete location problems, or the so-called discrete ordered median problems, have been widely studied in combinatorial optimization, whereas the capacited version of the problem has not.

In this work we present a new formulation for the aforementioned, based on a previously presented formulation for the Single-Allocation Ordered Median Hub Location problem (J.Puerto, A.B. Ramos, A.M. Rodríguez-Chía, and M.C. Sánchez-Gil, to appear).

One way to improve the difficulty of the large size of the above formulation is to take advantage of some features of that model to reduce the number of variables. We show a reformulation that is based on taking advantage of sequences of repetitions in the λ-vector, which reduces the number of binary variables tremendously. See A. Marín, S. Nickel, and S. Velten (2010), or J. Puerto, A.B. Ramos, and A.M. Rodríguez-Chía (2013), for a similar reformulation applied to regular discrete location and to hub problems, respectively.

In addition, a strengthening of this formulation is also studied through the use of some families of valid inequalities, as well as some preprocessing phases for fixing variables.
In order to test the performance of the proposed solution method, 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 proposed improvements.

COURNOT-STACKELBERG GAMES IN COMPETITIVE DELOCATION

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During economic crises, the number of commercial facilities decreases. Many firms need to reduce their network minimizing the market share lost. We address the problem of facilities closing in a duopolistic market considering three ways of behaviour: myopic, Cournot and Stackelberg competition. We present a binary integer programming formulation, and provide an algorithm to find the non-cooperative solutions. The existence of Nash equilibrium is empirically tested.

THE GENERALIZED DISCRETE (r|p)-CENTROID PROBLEM

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In this work we consider a discrete competitive location model which is called ($r|p$)-centroid problem, leader-follower problem or Stackelberg problem in locations. The model represents a situation where two players, the leader and the follower make decisions sequentially in order to reach certain objectives. Leader and follower want to determine the locations for p and r facilities respectively. The objective of the follower, who makes the decision once the leader has selected its locations, is to maximize the demand captured by its facilities. The objective of the leader is to minimize the maximum demand that the follower could capture, as demand is assumed to be essential, this objective is equivalent to maximize the demand captured by its facilities. We consider a generalized model in which the customer's choice rule is defined using a non-increasing capture function. The demand captured by the players is given by the value of this function for the difference between the distance from the demand point to the follower and the distance from the demand point to the leader. Given the set of p locations for the leader, X_p, the solution for the follower is an ($r|X_p$)-medianod. The solution for the leader is an *(r|p)*-centroid. We present a linear programming formulation for the generalized ($r|p$)-centroid problem and show some examples and results considering different capture functions.