EURO WORKING GROUP
ON LOCATIONAL ANALYSIS

UNIVERSITÀ DI NAPOLI FEDERICO II
Dipartimento di Ingegneria
Economico-Gestionale

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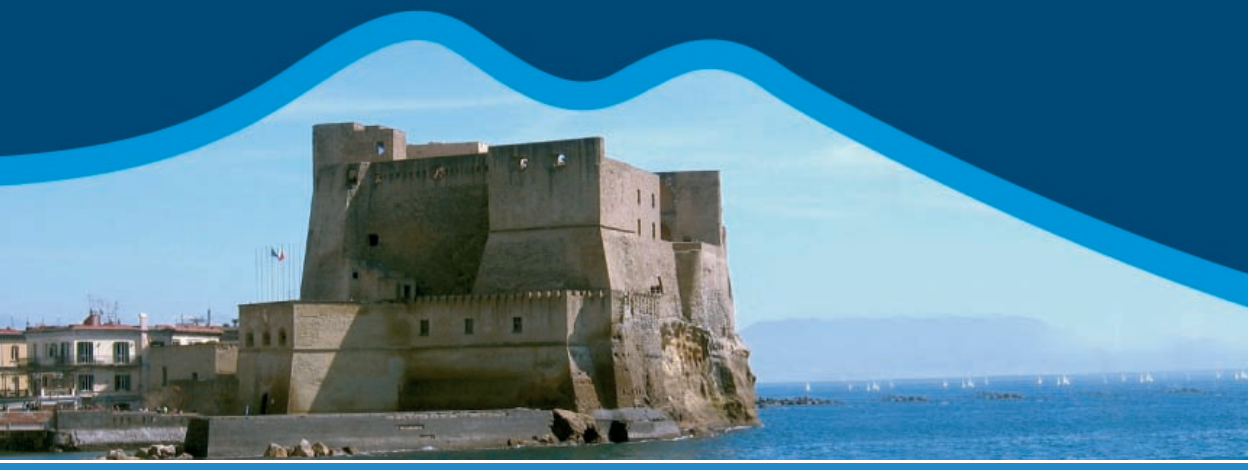
EURO WORKING GROUP
ON LOCATIONAL ANALYSIS

XVIII ewgla naples

Proceedings of the XVIII EWGLA Meeting

Naples, 28-30 April 2010



FEU

Euro Working Group on Locational Analysis

Proceedings of the XVIII EWGLA Meeting
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Editors:
Giuseppe Bruno
Andrea Genovese
Gennaro Improta

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INTRODUCTION

Dear EWGLA XVIII Participants,

I am pleased to give you the warmest welcome on behalf of the School of Engineering of the University of Naples Federico II which is hosting the meeting.

The University of Naples Federico II is one of the oldest academic institutions in the world having been founded by the Holy Roman Emperor Frederick II von Schwaben in 1224. Its Faculty of Engineering is one of the oldest and largest in Italy, first established in 1811 during the Napoleonic occupation of the Kingdom of Naples. Joachim Murat, King of Naples and Napoleon brother-in-law, decreed the foundation of the "Scuola di Applicazione di Ponti e Strade" (School for the construction of bridges and roads) on 4th March 1811.

After Italy's Unification, in 1863, the school took the name of Royal School of Engineering and was made directly dependent from the Ministry of Education of the new unified Kingdom of Italy. In 1904 the Royal School of Engineering changed name into Higher Polytechnic School (Scuola Superiore Politecnica) and was finally transformed into the Faculty of Engineering of the University of Naples in 1935. Since then the Faculty has developed fast and nowadays offers more than 20 degree courses, several MSc Programmes and Doctorate Schools, with more than 18,000 enrolled students. In 2011 the Faculty will be celebrating the 200th anniversary of its Foundation.

I hope you will have a successful meeting, and you will enjoy your staying in Naples, trying to find some time to discover the impressive heritage of our city and its neighbourhood.

Edoardo Cosenza
University of Naples Federico II
School of Engineering Dean

Dear EWGLA XVIII Participants,

as Chair of the Management Engineering Department (DIEG) of the University of Naples Federico II, I am glad to welcome you to the XVIII edition of the EWGLA meeting.

Established in March 2000 at the Engineering School, our Department provides cutting-edge research in several fields, like Business Management, Evaluation, Operations Management, Operational Research. Our research aims at integrating different approaches to deal with complex problems, in order to provide companies and policy makers with robust and reliable solutions. The Department is involved in various research projects through the collaborations with private and public enterprises and institutions. Research interests are focused on Knowledge Management, Supply Chain Management, Social Network Analysis, Project Management. In this field of the Operational Reseach group, traditional research topics are represented by Logistics, Transportation Planning, Traffic Control as well Locational Analysis.

DIEG provides support to all the degree and master degree programs active at the Engineering School of University Federico II through classes and seminars in related disciplines. Moreover, in 2006, the international PhD Program in Science and Technology Management has been activated, thanks to the cooperation with universities and research institutions from all over the world.

The organization of the XVIII EWGLA Meeting has been the result of an effort of the whole department and, for this reason, we hope you will enjoy your staying in Naples appreciating our organizational effort to make this meeting a successful forum for exchange of recent experiences and results.

Gennaro Improta
Chair of the Management Engineering Department
University of Naples Federico II

Dear Locators,

I'm delighted to welcome you to the XVIII EWGLA Meeting in Naples. As many of you know, the meetings of the European Working Group on Locational Analysis aim at bringing together researchers and practitioners working in the wide context of Location Science through the proposal of models and methods to solve both theoretical and practical problems.

The success of the previous editions witnesses a significant interest of the research community on the Locational Analysis. In particular, despite the challenging economic times, the current edition includes more than 70 contributions belonging to different traditional areas of the Locational Analysis and to topics related to various applications. The large number of submitted papers has constrained us to partially change the traditional format of the meeting into a single plenary session, allowing for some parallel sessions.

The presence of authors from 21 different countries confirms that EWGLA meetings represent an extraordinary opportunity to enrich relationships and to share experiences among locators from all over the world.

I'd like to thank the EWGLA board and all the colleagues of the Committees that have supported the organization of the meeting.

A special thank to Dr. Andrea Genovese for its valuable help in the organization.

Giuseppe Bruno
Chair of the Scientific Committee
of the XVIII EWGLA meeting

Foreword by the EWGLA Coordination Board

Since its creation in 1984, EWGLA – the EURO Working Group on Locational Analysis – has experienced a significant growth and has become a privileged vehicle of communication between all people with interests in Location and related topics in Operations Research in Europe and abroad.

The major goal of EWGLA is to stimulate the exchange of information and collaboration in research and applications, and to promote the ideas and methods developed within the field. The regular EWGLA meetings have been one of the main instruments for achieving this goal.

For the first time a EWGLA meeting – EWGLA XVIII – is held in Italy, organized in the beautiful and historical city of Naples, hosted by the University of Naples Federico II.

EWGLA meetings have always been an enjoyable and very friendly come together of an enthusiastic and energetic group, stimulated by the common interest in location related research. We are sure that EWGLA XVIII will not be an exception to this.

We thank to the organizers of EWGLA XVIII by their commitment, work and enthusiasm throughout the process that now concludes in Naples.

We wish to all participants a very successful and fruitful meeting.

Finally, we invite those who are still not EWGLA members to join the group. In the EWGLA website, www.ewgla.eu, the information on how to become a member can be found.

Alfredo Marín
Stefan Nickel
Francisco Saldanha-da-Gama

APPLICATIONS

Mathematical models for interurban traffic police location

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In E.U. countries, road collisions are the main cause of death for those aged 45 years and below and the total socio-economic cost of road crashes is estimated at over 160 billion euro. Road safety improvements draw from various disciplines including engineering, education and enforcement. These improvements have influenced car design, human behavior, infrastructure and the environment. 50% of the fatal accidents currently occur on interurban roads and in this research we focus on interurban traffic police location in an attempt to answer the question of how police forces should plan their everyday activities. The models are based on the road safety and criminology literature, police operations, policing policy and system constraints.

The problem is first analyzed as a set covering problem to determine the minimum number of patrol cars required to cover the network and then as a maximum covering location problem with additional constraints in order to locate the positions of routine patrol police vehicles such that all nodes of the network can be reached within an exogenous maximum arrival time. Since there are multiple feasible covering solutions, the different solutions are modeled as a multi-objective linear programming problem (MOLP). The objectives used are “presence and conspicuousness”, “ability to apprehend traffic offenders” and “other enforcement tasks”.

The set of MOLP solutions provides decision makers with the trade-offs between the different set coverings and a basis on which to operationalise the schedule of interurban vehicle location.

Optimizing Fire Station Locations for Istanbul Metropolitan Municipality

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The city of Istanbul, Turkey is a densely populated metropolitan city inhabited by 12.6 million residents. The city extends both on the European and Asian sides of the Bosphorus covering an area of some 1830 square kilometers. Istanbul is also under constant earthquake risk due to the fact that she lies in close proximity of a major fault line. Effective fire coverage by stations located strategically around the city is thus an absolute necessity for protecting human lives and property as well as more than 2000 years worth of architectural and archeological heritage. In this paper, we provide a guideline to the authorities of the Metropolitan Municipality of Istanbul in their attempt to determine the optimal locations of fire stations in addition to the already located ones. For this purpose, we present a max-cover based integer programming model that serves to increase the service speed and the coverage area of the fire departments. The basic model operates under the assumption of a limited investment budget and we solve it to optimality using GAMS to produce a solution that increases the existing fire coverage from 56% to 86%. We then solve variants of our model where we consider what-if scenarios such as unlimited budget, re-locating all fire stations from scratch, and finally solving with and without weight on cultural and historical treasures. We use a Geographic Information System (GIS) to store and retrieve all geographical input data of our model, calculate network distances among candidate locations and sub-districts subject to coverage, calculate fire coverage ratios and visualize various solutions of our model. The mathematical model in conjunction with the visual GIS interfaces we employ serve as a decision support system for the Municipality authorities to be used in future analyses.

Meeting points positioning in Newspaper distribution

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We consider a newspaper distribution problem that combines location and routing decisions. The problem deals with print shops, depots, customers and a heterogeneous fleet of vehicles. The newspapers are printed in print shops and transported to depots. From depots newspapers are distributed to customers directly or via meeting points. A meeting point is a place where one vehicle brings newspapers, which are then split and loaded into several vehicles. After being loaded, the vehicles either start or continue their routes from the meeting point, and distribute newspapers to customers. All customers have time windows that cannot be violated. The goal is to find good locations for meeting points and to generate cost-effective vehicle routes such that all customers are visited by exactly one vehicle in specified time windows. The research is motivated by real life newspaper distribution problems in Denmark and Sweden. The meeting point concept has been invented by dispatchers, since meeting points are crucial for time window constraint satisfaction and for decreasing the total sum of route lengths.

We will describe a mathematical model based on multi commodity network flows and a metaheuristic based on simulated annealing ideas. Also, we will present results obtained for several problems and compare cases with and without meeting points.

Location/Clustering problems emerging from the analysis of the World Value Survey Data

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Values of European citizens are periodically surveyed and made available through the Internet, for example from the web-sites of World Value Survey and the Eurobarometer. Those data are then analyzed through statistic techniques, and one of the most used is cluster analysis. In this way European citizens are classified into homogeneous clusters according to social categories. For example an individual can be classified as "religious" or "secular" and the modification of the European values can be tracked along the years.

One of the main technique that is used to social researchers to analyze those data is cluster analysis, see Inglearth et al, 2000; Weigel et al. 2003, Gubert et al. 2006, and optimal clusters are determined using algorithms embedded in statistic software, like SPSS.

In this communication, some results related to the application of cluster analysis to the WVS data are surveyed and some direction of research are described. Those are related to:

1) How to compute distances between individuals, that are measured through responses in a Likert scale.
2) K-means versus p-median models for data clustering.
3) Optimization of probability models for parametric clustering.

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An Optimization Mathematical Model and an Exact Algorithm for the Sensor Location Problem

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The problem of locating sensors on the network to optimize certain objective criteria has been object in the past few years of growing interest for its relevance in the context of traffic management and control. The addressed problems in the literature differ from each other according to the typology of sensors that can be located and to the objective functions to be optimized. In this paper we focus on the *Sensor Location Problem*, that is the specific problem of optimally locate counting sensors on the nodes of a traffic network to determine arc flow volumes on all the network. If we assume to know the split ratios associated with the nodes of the network, it is possible to derive from a subset M of nodes of minimum size such that the associated system has a unique solution (the Sensor Location Problem -SLP). We refer to such a set M as a monitoring set.

This problem was formally stated in Bianco et al. (2001), where a necessary condition for a subset of nodes to be a monitoring set has been stated. Such a condition was refined in Morrison and Martonosi (2008), and shown to be necessary and sufficient when the underlying graph is a tree. In Bianco et al. (2006), a combinatorial analysis of the problem was developed and the computational complexity of the problem was studied in different special cases. Moreover, some graph classes, where the problem is polinomially solvable, were presented. We further study the problem by providing an exact Branch and Bound approach to optimally solve the problem, and a mathematical formulation that was still missing in the literature.

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A Consumer Based Approach vs. Optimality in a Maximal Covering Location Problem with Price Decision

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The question adressed in this paper concerns the impact of feasibility constraints and consumer behavior on the optimal solution of a locational analysis model.

The Maximal Covering Location Problem with Price Decision by Plastria and Vanhaverbeke [2009] maximizes a firm's revenue by choosing optimal locations for a budgeted number of outlets and a price, set equal for all customers. These choices are based upon the decision making process of the customers, which is assumed perfectly rational.

Where prices are concerned, as put forward by the model's designers in their concluding remarks, certain practical restrictions were not taken into account. Firstly, any feasible price may not have more decimals than the smallest available subunit of the currency. Secondly, the government may choose to impose price regulations e.g. on necessity goods. The relation between the severity of these regulations and the solution of the model is examined. Implementing these restrictions is shown to reduce the needed computational effort drastically.

The original model was implicitly based on a wholesale environment where customers are indeed perfectly rational and the necessary information is freely available. Here a more consumer oriented approach is developed, comprising certain elements of bounded rationality and imperfect information. These elements, including the price level effect, were derived from consumer behavior literature. Procedures from the original model are subsequently adapted to reect the underlying consumer decision making process more accurately. The comparison between the perfectly rational, wholesale model and a consumer based, retail model is made. Both the optimality of the solution as well as the required computational effort are considered.

References

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Models and Methods for Wind Farms Location Decisions

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In recent years, increased environmental consciousness and attempts to lower greenhouse gases emissions have favoured the development of various renewable energy technologies. Wind power is one such form of renewable energy that is experimenting growing use and commercial success.

Moreover, ambitious national and EU programs have been developed in order to further increase the installed wind power capacity. To achieve the fixed objectives, new wind farms will have to be built up. These farms, in addition to being economically viable, should have an insignificant impact on the local environment in terms of visual and noise intrusion, electromagnetic interference and possibly wildlife collisions. Thus, location decisions regarding wind farms are crucial. In particular, location decisions arise at several stages in the building process of a wind farm: at a macro level, given a region and a set a constraints, a suitable area has to be identified for building up a wind farm; then, within the selected area, based on its characteristics, turbines have to be located in order to maximize the energy output.

In the literature, very few approaches have been proposed to deal with the location process of wind farms. Furthermore, these approaches deal with single stages of the location process, not providing a unified approach. Mosetti et al. (1994) propose a genetic algorithm to optimize wind turbine positioning in large wind farms; Baban and Parry (2001) develop and apply a GIS-based approach for locating wind farms in UK, also defining several location criteria by means of a survey questionnaire. Grady et al. (2005) illustrate some improvements to Mosetti et al. (1994) genetic algorithm, while Lange and Hehl-Lange (2005) build up a model based on more qualitative criteria.

In this study, a complete analysis about all the location decisions connected to the building of wind farms will be analyzed in detail, then proposing mathematical models and algorithms for solving the problem both from a macro and micro perspective.

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A model for the residential location choice in a land use and transport interaction framework

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In this paper, in the land use and transport interaction framework, the type of link (a correlation or causality) between the built environment and the travel behaviour has been investigated taking into account the relationship between neighbourhood characteristics, such as preferences and attitudes, and travel behaviour: specifically, whether neighbourhood design influences travel behaviour or whether travel preferences influence the choice of neighbourhood.

A survey has been conducted in the Rome metropolitan region in order to calibrate a residential location choice model Parameters calibration has been conducted adopting different advanced functional distributions.

Application of RFID to the Baggage Handling System of Fiumicino Airport

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The study deals with the application of Radio Frequency Identification Data (RFID) to the Baggage Handling System (BHS) of an Airport Terminal.

In fact problems related to the handling time are common for a BHS with a strong impact on all the derived airport operations. In particular, bags can be subject to delays, affecting the flights departure times and, moreover, bags can be often lost reducing the customer satisfaction.

The object of the research is to verify if the adoption of advanced tracking technologies such as RFID can reduce these problems and to quantify the improvement respect to the system actually adopted (usually bar-code).

The problem is formulated as an optimization problem aiming at minimizing the difference between the incoming bags flow and the outcoming bags flow (i.e. to reduce the number of not delivered bags). The model of BHS is realized using the ARENA simulator and considering the main decision variables:

– Conveyor belts speed;
– System capacity (number of bags for minute);
– Human resources needed along the belts;
– Percentual of read tags with RFID.

Different hypotheses have been adopted to represent the bags generation phase, considering if bags are generated at the analyzed airport, or they are passing through the airport. A real application related to the National flights Terminal of Fiumicino Airport (Italy) is performed.

Optimal location of safety cameras at urban intersections for road accidents control: a pilot study in the city of Rome

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In the last years a growing attention is being devoted to the application of technologies to increase safety on urban transportation networks. According to the data collected and presented by ACI-ISTAT [1], the number of car accidents registered in Italy during the year 2008 equals 218.963 and most of them (76.8%) happened at roads and intersections within the urban areas. Recent studies [4] confirmed that the installation of safety cameras at urban roads intersections can be an effective tool for reducing the number of collisions. An effective implementation of the public administration policies in this sense requires the maximal efficiency, taking into account the limited availability of budget. In this talk a quantitative approach for the optimal location of safety cameras at urban road intersections is presented, oriented to maximize the expected control and accidents reduction effect by exploiting great amounts of historical data on the location and the characteristics of the past road accidents. To his aim, an integrated use of geographical information systems and statistical analysis is proposed to individuate *black-spots* [3, 5] on the urban transportation networks, namely, those areas characterized by a high risk of accidents according to the elaboration of the collected historical data. Afterwards, the problem of the optimal location of safety cameras is formulated and solved as a *maximal covering location problem* [2]. The results of a pilot study are presented and discussed, concerning the application of such a methodology to a set of real data concerning road accidents happened in the city of Rome between the years 2006 and 2009.

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A Bankruptcy Approach to Ambulance Location Problem

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The location of the emergency units may have a deep influence on the intervention time, that in its turn may be relevant for a positive solution of an emergency situation. We are interested in those particular situations for which the utility of the intervention has a discontinuity, e.g. statistical analysis of ambulances that are allowed for a maximal time for the most difficult situations. The problem is tackled using different approaches based on bankruptcy problem solutions. Bankruptcy problems may be applied for allocating a scarce resource and ambulance location fits the model, as the number of ambulances available is far below the requests. The solutions may be oriented to efficiency, i.e. to cover the maximum number of calls, or to equity, i.e.to cover the maximal area or to an intermediate point, i.e. to reach as many people as possible.

The area under consideration is divided according to a grid and a number representing its value is assigned to each zone, whose meaning depends on the point of view we choose. We consider an a priori aggregation of the values of the zones an ambulance can cover and an a posteriori aggregation. In both cases the number of ambulances assigned to each location have to be an integer number, so the problem of round- ing the results arises

The test refers to a real world situation of locating some ambulances in the province of Milan.

Location Models for Helicopter Emergency Medical Service System

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In this paper, we propose location models for helicopter emergency medical service systems in which helicopters are used to carry emergency patients to a hospital as quickly as possible. In this situation, helicopters require heliports to land and pick up patients. When a critical accident occurs in a certain site, the patient is transported by an ambulance from the site to a heliport, and is picked up at the heliport and transported to a hospital by a helicopter.

Therefore, the transportation routes of ambulances and helicopters and the locations of helicopter stations and heliports are important factors to ensure the effective operation of the system. We propose min-sum and min-max location models and their mixed integer formulations, which seek to simultaneously find locations of stations and heliports to achieve effective transportation.

We present some numerical examples using idealized city models and explore how the shapes of the city and the distributions of demands affect the optimal locations of heliports and helicopter stations. We also examine the effect of the number of heliports and helicopter stations on the level of services provided.

Multicriteria Decision Analysis and Geographic Information Systems (GIS)

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Geographic Information Systems (GIS), today, is an information-technology based knowledge system providing all kinds of positional and spatial descriptive information in a related format. In other words, it is a system including processing, management, analysis, modeling, and imaging operations of positional and spatial data and having components as software, hardware, data, and humans.

Geographic Information Systems is required in almost all types of enterprises today and they play an important role in the solution of corporate problems as a corporate decision support system.

In an enterprise with a modern set-up, each department of the enterprise uses the same (common) data on positional and spatial basis. For example, service units of an establishment such as engineering services, planning department, marketing, construction department, etc. can make rational evaluations using the same positional and spatial data. The level of technology obtained today is able to integrate the data in question and provides the possibility of sharing. The two most important components of this technology are Geographic Information Systems and the Internet. Using Geographic Information Systems jointly with the facilities of the Internet environment eliminates spatial and time dependent limitations.

In this study, by using GIS, showing some example related to supply chain management, electronic business platform and mobile GIS in corporate decision support system and for solving some problems.

Planning Analysis for Locating Alternative Fuel Stations: the Case of Natural Gas Stations in Pozzuoli, Naples

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A world wide concern regards moving towards a more frequent use of environmentally friendly energy source. The pollution is one the heaviest issue to deal with in our community and the development of eco-friendly fuels could facilitate our commitment towards reducing this environmental threat.

The natural gas is cleaner than gasoline even though is still a fossil fuel. Today, the substitution of gasoline with natural gas corresponds to, in many circumstances, the easiest and feasible choice compared with a broad launch of hydrogen and electric vehicles. In many countries, one of the hurdles for a speeder diffusion of natural gas vehicles is the absence of an adequate spread system of gas stations.

According to this we addressed the problem of finding optimal locations for a gas station system in Pozzuoli, a town of 70.000 inhabitants close to Naples. Hence in order to define a master plan of the gas station system, we have implemented and compared the outcomes of three well-known location models: P-median, Simple plant location and Flow intercepting model.

The implemented P-median model chooses potential locations among the existing gasoline station positions and some new sites considering only user travelling costs. In addition to customer costs, Simple plant location model takes into account the costs of installing facilities (building and management costs), in two situations: (i) adding the natural gas service to the existing stations, (ii) installing new facilities.

As it is well-known, within these two models the demand is supposed to be concentrated in some nodes and the customer is willing to organize dedicated trips from its own position to the location nodes. In Flow interception model customers have a pre-planned trip and they are not willing to deviate from their path to reach the gas station and then they will exploit a gas station only if it is belonging to their path.

The plan of locations, obtained by the three models separately, can represent the starting point for private investors interested in building up new facilities. A facility manager, undoubtedly, will evaluate some other aspects not included into the plan such as the market competitiveness, the advantages and drawbacks related to the activity. In other words the final location choice could be seen as the combined result of a planning location analysis (made by a public Agency) and a further market analysis (made by a private investor).

Modeling the impact of policy variables, ICT- use and teleworking on the residential relocation decision in island areas

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The purpose of this paper is to provide an insight into the effects of ICT-use, teleworking opportunities and policy variables (focusing on region accessibility and housing prices) to the residential location behaviour in island areas. A detailed literature review describing the state of knowledge on the relationship between ICT-use, teleworking and regional development patterns, together with the state-of-the-art on residential location modelling is firstly presented. A behavioral framework to model residential relocation decision in island areas, where preference is based on location merits, especially accessibility, is then proposed. The proposed modeling framework is developed on the basis of the state of the art, considering the method of discrete choice modeling (based on the Random Utility Theory).

A case study is then developed for the wider Aegean island area in Greece. Data were collected from 900 households in Greece during the year 2007. The respondents were set in hypothetical scenarios and 2015 was the reference year. These scenarios involved facilitators of teleworking adaptation, together with five policy variables for relocation decision, related to accessibility measures and housing prices at the proposed area. Additionally, four alternative types of islands were considered, regarding social and transport indices. Data were analyzed via discrete choice modeling. Findings suggest that the most significant policy variables for the residential relocation decision to an island area relate to reduction in housing prices, additionally to reduction in travel cost and time. More likely to relocate to the proposed island area are households currently living in urban areas. The socioeconomic and work characteristics of the possible relocators are found similar to the findings of related studies for urban areas. Regarding to the type of island choice for possible relocation, the relevant decision seems to be affected by both the quality of public services at alternative locations as well as the socioeconomic and work characteristics of the respondents. Finally, the sample enumeration method is applied in order to aggregate the results over the Greek population.

A methodological challenge is to create a bridge between the methodologies used in Location Analysis and in Discrete Choice Analysis, via the paradigm of residential location. Location Analysis focuses on the specification and estimation of a class of problems which refer to the location of facilities in a given space. Discrete Choice Analysis focuses on the specification and estimation of a class of problems that involve choices between a set of independent discrete alternatives, such as different islands in our case. The main similarities between the two mathematical techniques when considering the application of residential location decision, are a) a space in which a location decision has to be made; and

b) a metric that indicates distances between individuals and facilities. Note that in this paper, additionally to traditional distances, policy variables, ICT- use and teleworking opportunities are also used in order to redefine accessibility measures of the areas. The main difference between the two methodologies lies on the fact that in Location Analysis the location decision is made on a macro level based on the concept of the "total or aggregate demand" of a particular product or service. In Discrete Choice Analysis the decision in question is made on a micro level by individuals, households or firms, based on the decision makers' behaviour and the results are then aggregated to provide the overall population based on the relocation decisions. An interesting issue to be studied in a future research is how to merge the two methodologies so that their application would provide consistent, accurate and reliable predictions.

Investigating the information flow structure of the new product development process to localize performance bottlenecks

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The performance of the new product development process strongly depends on the way the underlying component tasks are interconnected and coordinated. Literature that studied the product development process from an information management perspective emphasized that the exchange of technical and managerial information affects decision-making, product development performance and risk (Brown and Eisenhardt, 1995; Fujimoto and Clark, 1995; Ulrich and Eppinger, 2000). The development of a new product often requires the completion of hundreds of closely coupled tasks, grouped into phases and stages, through which the concept, configuration and other technical details of the product are generated, narrowed, and finalized (Kim and Wilemon, 2003). Further, product development frequently implies rework and refinement to account for unexpected failure to meet target specifications or new more useful information and knowledge generated from downstream tasks after completing an expected iteration, thus modifying previously made decisions (Smith and Eppinger, 1997). The couplings and dependencies between product development phases need the exchange of product-specific information between development teams – i.e., the transfer of customer preferences from the marketing group to the design group that allows designers to generate and finalize the product concept and detailed design charts and drawings. As a consequence, understanding in depth the structure of information flows during product development can help gain insights to as how to improve the whole process, i.e. how to localize performance bottlenecks, streamline it, identify potential iterations, and effective coordination mechanisms.

This paper uses Social Network Analysis (SNA) to investigate the structure of information flows and the Dependency Structure Matrix (DSM) to model task interdependency in terms of information exchange between interacting tasks during new product development (Browning, 1999; Browning and Eppinger, 2002; Hanneman, and Riddle, 2005). The case of the climate system developed for a new car manufactured by a large Italian car OEM was investigated. Social Networks metrics were calculated to investigate the properties of the specific product development process, analyzing the information flow characters, and localize performance bottlenecks (Scott, 2000).

The analysis was supported by the continuous feedback from the technical managers and engineers involved in the subsystem development. A questionnaire was developed and administered to technical managers and engineers to collect data. Most of the data were collected using measurement scales designed for the purpose. Results relative to the application of the approach to the development of the climate system of a new car model developed by a large Italian car manufacturer are presented. This paper contributes to literature as it takes into account both ambiguity and uncertainty amounts to assess information flow quality. Limitations of the approach are also discussed.

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Optimal Assignment of Items to the Store Shelves in a Retailer Using Facility Location Models

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We consider optimal assignment problems in a retailer. In the retailer, the items are expected to be displayed considering the simultaneous purchase probability by customers. The items which are likely to be bought simultaneously by a customer should be placed nearby shelves each other. We use facility location models to solve the problem.

The retailer categorizes the items into two levels. The items are categorized by their usage into 'sectors'. For example, detergent, soap, etc. are categorized into daily goods sector. Next, a sector is divided into dozens of 'patterns'. A pattern is formed by items with the same generic name. For example, Pantene, Vive pro, etc. are categorized into the shampoo pattern. The layout is organized by a group of shelves called slot formed by ten shelves in a row. A sector of items is assigned to several slots, and several patterns are displayed in each slot.

The problem is to place the pattern, which is expected to become a big seller and has large simultaneous purchase probability with the other patterns, to the end of the slot called the end shelf along the main corridor. The problem is divided into two sub problems. The first is to select patterns which are assigned to the end shelves, and the second is to assign the rest of the patterns into the slot. The POS data of the retailer is analyzed to calculate the simultaneous purchase probability between patterns and to obtain the sales of each pattern. We formulate the first problem as the constrained p-median problem. In the formulation, the sales of patterns are considered as the weights of patterns, and the probability is considered as the distance between the patterns. We formulate the second problem as the travelling salesman problem. We solved the problems by an optimization software.

CONTINUOUS LOCATION

A robustness property in single-facility location with mixed norms

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The main purpose of this work is to show that any center coming from the single-facility location problem with mixed norms has an interesting robustness property. Furthermore, our presentation will be an opportunity for general considerations about robustness in facility location. Before giving some details, let us mention that this work has been done in the framework of the French ANR project ROLSES (Robust and Optimal Locations for Sustainable Environment and Systems). Consider the single-facility location problem with mixed norms seen firstly as a decision problem: one has to choose the position of a *center* which satisfies the demand located at n points for the cost associated to the minisum or minimax criterion and built on L_p norms associated to each point of demand.

The most classical answer to this decision problem is to minimize the cost.

Suppose now that there is some (deterministic) uncertainty about the positions of the demand points. Following an interesting idea of E. Carrizosa and S. Nickel (Robust facility location, Mathematical methods of operations research, 2003, vol. 58, n.2, pp. 331-349) who deals with uncertainty about the quantity of demand at each point, one can look for the most robust solution (in relation to this uncertainty) guaranteeing that the cost doesn't exceed a chosen value.

We will show that for the minimax or the minisum criterion, minimizing the cost is equivalent to searching for robust solutions in the sense described just before.

Ordered Median Problem with Demand Distribution Weights

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During the last decade a new type of objective function in location theory, called ordered median function, has been developed and analyzed [1]. This objective function unifies and generalizes most common objective functions used in location theory. It is based on the Ordered Weighted Averaging (OWA) operator with the preferential weights allocated to the ordered distances. Demand weights are used in location problems to express the client demand for a service thus defining the location decision output as distances distributed according to measures defined by the demand weights. Note that the model of such distribution weights allows us for a clear interpretation of demand weights as the client repetitions at the same place. Splitting a client into two clients sharing the demand at the same geographical point does not cause any change of the final distribution of distances. Therefore, the distribution model of weights is important to accommodate various demand coefficients in location problems. Typical ordered median model allows weighting of several clients only by straight forward rescaling of the distance values. However, the OWA aggregation of distances enables us to introduce demand weights by rescaling accordingly clients measure within the distribution of distances as defined in the so-called Weighted OWA (WOWA) aggregation [3, 4]. The WOWA aggregation uses two sets of weights: the preferential (OWA type) weights and the demand (distribution measure) weights. It covers as special cases both the standard weighted mean (the weighted median solution concept defined with the demand weights) in the case of equal all the preference weights, as well as the OWA averages (the ordered median solution concept defined with the preferential weights) in the case of equal all the demand weights. The WOWA operator is a particular case of the Choquet integral defined with quite a complicated formula. Nevertheless, linear pro-gramming formulations were introduced for optimization of the WOWA objective with monotonic preferential weights thus representing the equitable preferences.

This paper studies basic properties of the Weighted Ordered Median Problem (WOMP) taking into account the demand weights following the WOWA aggregation rules.

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Polynomials, semidefinite programming and Location Problems

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We introduce some tools borrowed from algebraic geometry to reformulate a wide family of locations problems (continuous and discrete) as a particular case of the generalized problem of moments. Then, we will prove structural results on general location problems that reduce their resolution to solving a finite number (at times one) of semidefinite programs.

We illustrate the general approach with some well-known examples as the Euclidean planar Weber and minimax problems, and the constrained planar anti-Weber problem among others.

The planar k-centrum problem with Euclidean distances

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This paper presents a solution procedure based on a gradient descent method for the k-centrum problem in the plane. The particular framework of this problem for the Euclidean norm leads to bisector lines whose analytical expressions are easy to handle. This allows us to develop different solution procedures which are tested on different problems and compared with existing procedures in the literature of Location Analysis. The computational analysis reports that our procedures provide better results than the existing ones for the k-centrum problem.

COVERING MODELS

Enhancing Demand Covering Models by Exploiting Data Envelopment Analysis (DEA) Efficiency Scores

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The objective of demand covering models is to locate facilities such that a given set of customers is sufficiently covered. Quite often, locating facilities at different sites may affect their ability to transform inputs into outputs and, consequently, their ability to provide adequate coverage. In this paper we present a series of models that utilize Data Envelopment Analysis (DEA) efficiency scores to locate facilities that cover some type of demand. By combining the DEA model with classical demand covering models such as the Location Set Covering Model (LSCM) or the Maximal Covering Location Model (MCLM), we consider two types of efficiencies: (a) spatial efficiency, as measured by location criteria and (b) facility efficiency, as measured by the DEA efficiency scores. We develop a series of bi-objective models that attempt to simultaneously optimize the coverage of the demand by the facilities and the performance of these facilities at their chosen locations. We illustrate the use of these models through a set of examples.

Source Location in Static and Dynamic Networks

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In an undirected capacitated network with flow demands and fixed setup costs for all vertices, source location problems find the "best", i.e. cost-minimal, location of sources such that the given demands are satisfied. To decide if a vertex subset is indeed a source set, the maximum flow values between all vertices are computed and, as such, these problems combine network flows and location theory. Depending on whether the underlying network and the corresponding flow are static or dynamic, that is, if time is involved or not, we study static and dynamic single cover problems in which the flow demand of a vertex has to be covered by a single source out of the chosen source set. Concerning the static case, we review existing concepts including a polynomial-time algorithm based on flow equivalent tree networks, the definiton of so-called (minimal) deficient sets as well as a related greedy type solution algorithm. For non-uniform demands or costs, we show some new results. In dynamic networks with time horizon Θ and additional travel times on the edges, static flows are replaced by dynamic flows and demands are satisfied whenever the maximal dynamic flow up to time Θ between a single source and a vertex is at least as large as its demand. Similar to static source location, we define and analyse (minimal) dynamic deficient sets and give an analogue dynamic single cover characterization. By reduction from set cover, the general dynamic single cover problem is proved to be NP-hard. Formulating the problem itself as set covering problem, there are however some polynomially solvable special cases.

Minimum Overlap Covering Models

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Standard covering location problems consider that a customer or demand is "covered" if it is within a threshold distance from at least one facility. When more than one facility is within the threshold distance, there is overlap between the coverage areas of two or more facilities. A customer located in such an overlap area is assumed to receive the service or good from exactly one of the facilities. However, there are cases in which multiple-facility coverage of a customer needs to be explicitly taken into account, because it either has synergic or destructive effects. Examples of destructive effects are found in broadcast networks using the Single Frequency Network concept (usual in digital TV transmissions), or in other telecommunications systems (5^{th} generation mobile telephony). Coverage of customers by the service is required; however if a customer has more than one facility within threshold distance, the second and following facilities act as sources of interference. In this case, facilities should be located so as to avoid redundant or overlapping coverage. A further example appears when locating landfills. A community may need having such a facility within a reasonable distance, but locating more than one in the neighborhood is an excessive punishment for a particular community.

We propose several models that maximize coverage, or minimize the number of facilities needed to cover all customers, while minimizing redundant or overlapping coverage as a second objective. We discuss different formulations, including both standard covering functions (steep functions of distance) and gradual covering functions; and we also locate variable coverage radius facilities and consider the case in which coverage and destructive effects have different radii. Finally, we analyze issues related to the customer facility assignment, and provide computational experience.

Expansions of the Queuing Maximal Covering Location Allocation Problem

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Marianov and Serra (1998) introduce the queuing maximal covering location allocation model -QMCLAM, which locates p centers and allocates users to these centers in order to maximize the covered population. Coverage is defined as (i) when patients are allocated to a center within a standard time or distance from home location, and (ii) when patients are served within time τ of arrival at the center, with a probability of at least α. Silva and Serra (2008) offer an expansion of the QMCLAM that considers different time standards for different priorities of healthcare service.

In our paper we develop some other expansions of the QMCLAM using different queuing models. A greedy heuristic adaptive search procedure is used to solve numerical examples that illustrate the differences between the several formulations.

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DISCRETE LOCATION AND SUPPLY CHAIN

Multicriteria location planning of urban distribution centers under sustainable freight regulations

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Location planning of urban distribution centers is vital in saving distribution costs of logistics operators, administration costs of traffic managers and minimizing negative impacts of traffic congestion arising from goods movement in cities. In this paper, we present a multi-criteria decision making approach for location planning of urban distribution centers under sustainable freight regulations imposed by municipal administrations. Examples of these regulations are restricted delivery timings and access areas, congestion pricing etc.

The proposed approach involves three steps. In step 1, we identify potential locations for implementing urban distribution centers and the evaluation criteria. In step 2, the decision makers evaluate the potential locations against the selected criteria. In step 3, expert ratings are aggregated through fuzzy TOPSIS to generate an overall score for the potential locations. The location with the highest score is recommended for implementation. Sensitivity analysis is performed to determine the influence of criteria weights on location selection. A numerical illustration is provided to demonstrate the proposed approach.

The strength of the proposed work is its ability to deal with uncertainty arising in location planning of urban distribution centers due to partial or incomplete information. The proposed approach can be practically applied by city transport organizations and logistics operators for implementing new distribution centers in cities considering the sustainable freight regulations imposed by municipal administrations.

Models and Algorithms for Multi-Echelon Distribution Networks

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The Multi-Echelon Distribution Networks is a problem arising in the configuration of many real-life logistic system. It is defined on a graph with depots and customers and to each depot is associated a capacity and a cost and to each customer is associated a demand. There are two different types of decisions that must be addressed in designing this distribution network. The first one is a strategic decision consisiting in opening one or more depots, on a given set of a priori defined depot locations, and to design, for each opened depot, a number of routes in order to supply the demands of a given set of customers. This problem is called Location Routing Problem (LRP) and the objective is to minimize the sum of the route costs and the fixed costs of the opened depots. The second decision is a tactical one consisting in designing a 1-st level set of routes form supplying the depots and a second level of routing problem for supplying the customers. This second problem is known as a Two Echelon Vehicle Routing Problem (2E-VRP) and the objective is to minimize the sum of the routing costs: first and second level. This paper describes several formulations of both problems and two exact methods for solving them, both based on a set partitioning-like formulation. Computational results on benchmark instances from the literature are presented.

Urban distribution facility planning considering product-mix

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Location choice of urban distribution centers is vital in saving logistics costs as well as providing improved services to clients. Recently, a new concept of city logistics is emerged as growing number of city municipalities are focusing on greener and congestion free cities. To reduce the pollution and congestion in cities, entry of heavy vehicles is either not allowed at all or restricted to certain specific time windows. In this work we assume the city has opened several cross-docking yards where heavy vehicles can transfer their loads to equivalent number of small vehicles (permitted vehicles) to distribute the products to their clients. The cost of loading –unloading has to be borne by the suppliers and city charges hourly usage fee for the dockyards. In this problem we assume the supplier uses these cross-docking facilities for product mixing to economize the transportation, however, product mixing has an adverse implication in terms of facility usage. The objective is to select a suitable or a best combination of cross-dock facilities to minimize the transportation cost as well as the facility usage costs for the supplier.

The overall facility planning and urban distribution problem is a non-linear integer program. We propose a Dantzig-Wolfe decomposition based algorithm to solve the problem. Numerical study will be provided to illustrate the approach and demonstrate the perfomance of the algorithm.

Location or Allocation – what to consider first?

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Many well known location models involve two types of decisions: 1) selecting the desired locations for the sources, and 2) allocating customers' demand to the located sources. This includes the p-Median, p-Center, Facility/Plant Location and other models. Models that involve these two decision types can be referred to as location-allocation (LA) models, and share a common set of constraint that link both decision types – no demand can be allocated to a location with no source! One solution approach starts by partially considering allocations – the customers' set is broken into subsets, each is allocated to a single source. This approach takes advantage of the fact that the location of a single source to a known set of customers is often quite simple. Each subset is represented as a column in the constraint matrix of a set covering (SC) model, whose solution selects the optimal partition of the customers' set. However, the number of columns in the covering matrix is, generally, exponential in the number of customers. Further, SC is not applicable for capacitated LA models, because in these models the allocation variables are not 0-1, since due to capacity limits the demand of a customer may be satisfied from more than one source. Consequently, the location of a source no longer depends on the allocated customers but on the allocated demand. Alternatively, subsets of sites can be considered. The allocation decisions to a given subset of sites at which sources are located is, in many cases, fairly simple. Moreover, often, the number of sites is smaller than the number of customers, much smaller in many cases. Hence the number of subsets of sites is much smaller than the number of subsets of customers in the SC approach. We present a scheme for the site selection approach and compare both approaches.

A multi-commodity two-echelon capacitated facility location problem with sizing decisions

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Classical discrete facility location problems address location and transportation decisions. In most cases, the costs associated with these decisions include fixed setup and operational costs. Frequently, the latter are determined by the utilization level of the facility, which is an important aspect that has not been extensively studied in the literature. For example, costs related to energy consumption depend on the degree to which a storage area is utilized. Moreover, a large facility often benefits from economies of scale associated, for instance, with sharing storage and material handling equipment among multiple products. We address this important issue by considering facility sizing decisions and variable operating costs in a two-echelon network. In each echelon and at each potential site, a new facility can be established for a group of product families. The size of the storage area occupied by a product family is to be selected from a discrete set of available sizes. Operating costs depend on the type of storage area installed in a given location for a product family and are charged to the total product quantity that is stored. The goal is to design a two-echelon network so as to minimize the total costs.

We discuss several modelling issues and valid inequalities leading to different new formulations. The results of an extensive computational study based on randomly generated data are presented.

The single source capacitated facility problem with additional constraints

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We propose a model which generalizes the single source capacitated facility location problem (SSCFLP). Unlike SSFCLP, this model imposes both a minimum and a maximum amount by which each customer has to be served. If the maximum amount is not reached a penalty cost is applied. This penalty cost depends on both the customer and the number of undelivered units. In addition, facilities also have their capacity bounded. The lower bound establishes the minimum amount required to open a facility whereas the upper bound the available capacity.

This problem can be formulated as a Mixed Integer Linear Program with a total of 2xnxm+n decision variables and 2xn+m+2$xnxm$ functional constraints where m represents the number of costumers and n represents the number of potential locations for facilities. We propose a heuristic based on metaheuristics methodologies. Computational experiments on different data sets are presented and the corresponding solutions are discussed.

Benders' decompositions for reverse logistics location problems

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Reverse logistics activities are often supported by specific facilities. These are mainly of two different types: collection centers and recovery facilities. As a result, it is possible to associate a network with the reverse activities leading to a so-called reverse network.
For additional details and references see Melo et al. [2].

A key aspect that often is unavoidable in reverse logistics refers to the uncertainty on the amount of return products that will flow through the network. This aspect has been studyied in Fonseca et al. [1] along with other aspects such as the obnoxius effect, different capacities or technologies of some facilities. In the model presented in this paper two objectives are considered simultaneously: cost and obnoxius effect.

When considering the obnoxious effect function, the model is relatively easy to solve for real-world instances, but when using input data for real-world instances and when considering the cost objective computationals time needed to solve the model may be very different and sometimes very high. Thus, the authors are working on reducing the computational time for solving real instances.

In this work we present our advances on applying different Benders' decomposition methods to the problem presented in Fonseca et al. [1] but only with the economic objective. This two stage stochastic model does not have a so-called relatively complete resource, i.e, for any feasible first-stage solution, the second-stage problem is not always feasible.

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Disaster mitigation strategies against disruptions with ripple effects

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Facilities providing essential goods and services are often vulnerable to external disruptions, ranging from highly catastrophic events, such as hurricanes, earthquakes, fires and terrorist attacks, to less dramatic but just as severe disruptions, such as labour strikes, contaminations, and power outages. The damage caused by such events is rarely circumscribed to a single facility. More often, the loss of one facility can have cascading effects on other system components either within its proximity or those operationally dependent on it.

In this work, we address the problem of identifying optimal protection strategies for service and supply systems so as to improve their reliability in the face of large area disruptions, i.e., disruptions that affect regions rather than single elements of the system.

Specifically, we propose a protection model which identifies the optimal allocation of limited protection resources among the facilities of a capacitated median system. The aim of the model is to minimize the impact of a worst-case disruption to the system where the disruption on a given facility reduces the operational capacity of that facility as well as the capacity of other facilities in its vicinity. We assume that the capacity reduction of the other facilities is proportional to the distance from the facilities which are directly hit by the catastrophic event. This model is referred to as the Wave Propagation R-Interdiction Median Problem with Fortification (WaveRIMF) and is formulated as a tri-level program. We present two optimal and two heuristic algorithms to solve WaveRIMF and report some computational results obtained by applying the model to a hypothetical dataset.

Lower Bounds for a Capacitated Facility Location Problem with Penalties and Revenues

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We consider a variant of the Capacitated Facility Location Problem in which the demand of each costumer may not be entirely supplied.

In this variant, the available supply is not enough to satisfy the total demand. However, for each costumer, a minimum proportion of the demand is guaranteed and a penalty is associated with each unit left out.

On the other hand, each costumer can be supplied by more than one facility. Nevertheless, satisfying the demand of a costumer entirely by exactly one facility is aimed. If this condition is satisfied revenue is considered.

We propose a formulation for this problem. We also propose valid inequalities to augment the Linear Programming relaxation in order to improve the lower bounds.

Correlation and Disruption Induced Effects on Location Problems Strategic Centralization and Co-Location Problem

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We analyze the problem of locating two facilities prone to failure on a line. A variety of objectives is analyzed both under independent and correlated failure scenarios. The total cost is decomposed into informational, reliability and locational components. Interesting insights about optimal location patterns under different scenarios are obtained which reinforce insights previously obtained for the case in the network.

Worst-Case Bounds of Myopic Location for Submodular Function Maximization

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In the past, the problem of maximizing function subject to a cardinality constraint have been studied by some papers. This problem is NP-hard, so many heuristics such as greedy and interchange heuristics have been developed in order to obtain suboptimal solution for the real-world problem, and to provide an initial solution for applying exact algorithm such as branch-and-bound method. The median models, center problems and uncapacitated location problems, which are typical location models, are special cases of the submodular maximization problem. In addition, myopic methods such as greedy and stingy methods might be more desirable in an actual application, thought the solution obtained by using myopic methods would not necessarily be optimal.

Nemhauser et al.(1978) provided a worst-case bound for myopic heuristics such as greedy, stingy and exchange heuristics. This bound is useful for decision-makers because they can understand how myopic solution value is far from the optimal value.

Although the seminal work by Nemhauser et al.(1978) provide a richer theoretical background on the efficiency of myopic methods for location analysis, it does not take account of the size of the set, i.e., the number of potential facility sites. In general, the number of potential facility sites is quite small because it may be difficult to get a consensus from neighborhood. This allows us to expect that we can get a better approximation than the bound by Nemhauser et al.(1978). The objective of this paper is to show such a better bound by considering the number of potential facility sites.

A Generalization of Location-Allocation Problem Unified with Number and Size of Facilities

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In this paper, we discuss a generalization of location-allocation problem to deal with size and number of facilities simultaneously. Various model is proposed to solve facility location problem. Most of those require the number of facilities in case of multiple facility. In the hierarchical model, size at each level is necessary in addition to individual number. To treat in unified way, we make some suppositions concerning total cost of facility users, and relation between services and size of facility.

We assume that facility provides some public service and its construction cost and operating cost are managed by usage fee and/or tax. Facility provides some kinds of service depending on its size. And size of facility determines their construction and operating costs, that is managing cost is a function of facility size. To simplify the problem, we assume the kinds of service provided at a facility are successively inclusive. That is, facility provides all the kinds of service which are provided at smaller size facility. Furthermore, we assume users exist in a region, and demands for each service are known.

Then, users must pay travel cost from their home to facility which provides services satisfying their demand, and share managing cost of facility as usage fee. Our objective is to simultaneously determine location and size of facility and allocation of users which minimize a total of travel cost of users, construction cost and operating cost of facilities. The very small size means that there is no facility any more, because it provides little service. Therefore, optimal number of facilities is obtained in above solution. We formulate the problem as a mathematical programming problem, and obtain some interesting results. Many varieties of both size and number about facility are obtained depending on relation between distribution of demand and construction cost.

HUB LOCATION

Multimodal Hub Location and Hub Network Design Problem

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Hubs are special facilities that serve as switching, transshipment, and sorting points in many-to-many distribution systems. The hub location problem deals with finding the location of hub facilities and allocating the demand nodes to these hub facilities so as to effectively route the demand between origin–destination pairs. Hub location problems arise in various application settings in telecommunication and transportation. In the extensive literature on the hub location problem, it has widely been assumed that the subgraph induced by the hub nodes, the hub network, is complete.

In this study, we approach the hub location problems from a network design perspective. In addition to the location and allocation decisions, we also study the decision on how the hub networks with different possible transportation modes must be designed. In this context, we introduce the multimodal hub location and hub network design problem. In this problem, we jointly consider transportation costs and travel times, which are studied separately in hub location problems presented in the literature. We include the possibility of using different hub links, and allow for different transportation modes between hubs, and for different types of service time promises between origin–destination pairs, while designing the hub network in the multimodal problem. We propose a linear mixed integer programming model for the problem together with some sets of effective valid inequalities and an efficient heuristic. Computational analysis is presented using the Turkish network data set.

Hubs location for freight transport in urban areas

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It is well known that many advantages can derive from using logistic platforms in urban areas. In this work we deal with the problem of identifying where to locate hubs for freight transport in urban areas, taking into account both the present urban logistic network and congestion and pollution problems, that strongly affect the life quality.

First, we focus our attention to the identification of those nodes that could be attractive poles for modal exchanges for freight mobility within a urban intermodal transportation network, thus becoming logistic platforms. In particular, we select the possible modal exchange nodes by analysing their communication capabilities (i.e. connectivity and reachability) with the other nodes of the network, such as depots, transit points, retail points, main accesses to the highways and railways.

Successively, we use a heuristic algorithm for computing optimal origin – destination (o-d) routes in the given urban multimodal transportation networks. The algorithm looks for the best possible interchange nodes and computes the minimum cost path using such nodes for the pair of o-d nodes under consideration. In particular, by using a Dijkstra like algorithm, we first compute the shortest mono-modal paths by looking for the most well performing exchange nodes from both the origin and the destination nodes; then, we evaluate the generalized cost of the corresponding possible multi-modal path forcing as much as possible routings through those nodes that are suitable for being selected as commuting points.

Finally, we use the set of candidate logistic platform nodes for identifying the best location of hubs in the whole transportation network.

The propose approach has been applied to the logistic network of the city of Genoa. First we illustrate the resulting graph model, having 880 nodes and 1760 arcs, whose total length is 2280 kilometres. The generalized cost function that is considered in the computation of the shortest paths counts for different means, such as cars, motorbikes, delivery vans, delivery trucks and buses. Experimental results, showing some traffic reduction, especially through the most congested nodes, are presented.

Single-assignment hub location problems with multiple capacity levels

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An extension of the classical capacitated single-allocation hub location problem is proposed in which the size of the hubs is part of the decision making process. For each potential hub location a set of capacities is assumed to be available among which one can be chosen. Some formulations are proposed for this problem, which are compared in terms of the bound provided by the linear relaxation. Different sets of inequalities together with some preprocessing tests are proposed to enhance the formulations. The computational experience performed to evaluate the formulations is reported.

A reduced formulation for the uncapacitated hub location problem

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The problem of locating hubs arises when a set of users of a system needs to exchange a certain product and they wish to exchange it by means of some special transhipment points which benefit from a economy of scales: the hubs. It has many applications in fields such as Telecommunications, Air Transport or postal delivery.

Particularly, here we study the multiple allocation hub location problem. We develop a reduced formulation, based on ordering the costs and using some properties of the Boolean quadratic polytope, which is strengthened with several valid inequalities. Finally, a computational study shows the performance of this model.

Hub Location Problems in Liner Shipping Network Design

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Certain type of hub-and-spoke network designs appears in the network of liner companies and alliances. From among such designs, transshipment in the hub-level subnetwork and transit between pairs of hub-level networks deserves more attentions. This presentation aims at introducing new variants of hub location problems addressing necessities of such network designs in the liner shipping industries.

LOCATION AND GAMES

Solving a Huff location model with uncertain demand

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We address the following single-facility location problem: a firm is entering into a market by locating one facility in a region of the plane. The demand captured from each user by the facility will be proportional to the users buying power and inversely proportional to a function of the user-facility distance. Uncertainty exists on the buying power (weight) of the users. This is modeled by assuming that a set of scenarios exists, each scenario corresponding to a weight realization. The objective is to locate the facility following the Savage criterion, i.e., the minimax-regret location is sought. The problem is formulated as a global optimization problem with objective written as difference of two convex monotonic functions. The numerical results obtained show that a branch and bound using this formulation to obtain bounds, clearly outperforms benchmark procedures.

A Hotelling Model with Delivered Pricing

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Competitive location models have been discussed since Hotelling's original contribution eighty years ago. While the original model assumes price and location competition given mill pricing, our model assumes that the duopoly firms apply delivered pricing given fixed and equal prices. However, we include different production costs with one firm being more efficient, i.e., having lower production costs than its opponent. We first establish the existence of a Nash equilibrium for the general case. Incidentally, in the special case of equal production costs, the firms locate at the first and third quartile of the market at optimum. An essential part of the equilibrium discussion involves a proof for the fact that it does not benefit a firm to undercut its opponent, a strategy that causes major problems in Hotelling's original analysis.

We then investigate von Stackelberg solutions, in which the leader firm locates with foresight. The analysis distinguishes between two cases: first we determine optimal strategies for the case, in which the more efficient firm locates first, and then the case, in which the inefficient firm locates first. Profits of the firms in the two cases are computed and compared with each other and with the equilibrium profits.

The last part of the paper investigates the effect of finite reservation prices on the solutions. Finally, the case of a uniform delivered pricing policy is discussed and solved.

The effect of production and transportation costs in locating new facilities under competitive delivered prices

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We analyze the problem of locating distribution points for an entering firm that competes in price with some established firms. There is a set of spatially separated markets which demand an homogeneous product. Each competing firm offers an equilibrium price in each market, which depends on the location of the distribution points. The suggested model is applied to analyze the effect of both the marginal production cost and the transportation cost on the location decision. We study variations on the profit of the entering firm when the new facilities location are offered by the resolution of the model. A study of sensitivity of the solutions when the delivered cost from any facility to any market varies linearly with distance is presented by using data of the Region of Murcia.

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A single-facility location-allocation problem with regional fixed costs

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Location problems deal with finding the best location for one or more facilities such that some objective is optimized. In a location-allocation situation, all the agents involved in the location problem want to find an optimal location of the facility (or facilities) as well as to share the corresponding total costs. This cost sharing problem, also called allocation problem, is approached by means of a Cooperative Game Theory tool, namely the core solution concept. Properties about the optimal location as well as the core allocations are presented for a continuous single-facility location problem under the assumption that the installation cost (or fixed cost) is zone-dependent.

Location Games on the Plane with Manhattan Distance

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We analyze the location game on the plane with Euclidean and Manhattan distance. There are some firms (players) located in different points of the city and the customers are distributed with some density in it. The players declare the prices for the goods. The customers compare the costs for a visit of each firm. The costs consist on the price plus the distance from the customer to the firm.

Some firms calculate the distance in Euclidean metrics and other in Manhattan metrics. It corresponds to the networking market with different types of connection (cable and wireless channels).

The solution of two game-theoretic problems is derived. The first problem is to find the equilibrium prices for the homogeneous goods and the second is to find the equilibrium allocation of the players.

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Competitive location models: an agent-based approach

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We aim to integrate the aspects of a complex retail environment and consumers' bounded rationality into the location analysis context. Therefore we first introduce Agent-Based Modelling and Simulation (ABMS), we narrow down the goal of the agent-based approach and provide artificial test results.

Usually basic assumptions are used to simplify systems to be modelled using traditional tools. In the context of location problems, ABMS allows to deal with some of the restrictions of the otherwise very powerful analytic models.

Especially the dynamic aspects of the competition among the retailers are useful to address. We think of the spatial interaction and price competition among the players on the market in the short run, but certainly over the long haul. Also bounded rational consumer spatial behavior is taken into account.

Finally, we show test results from an artificial data set.

Hub Arc Location with Competition

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In this paper, we consider the design of large-scale hub-and-spoke transportation networks in a competitive environment. We adopt the hub arc location model that locates arcs with discounted transport costs connecting pairs of hub facilities. Two firms compete for customers in a Stackelberg framework where the leader firm locates hub arcs to maximize its revenue, given that the follower firm will subsequently locate its own hub arcs to maximize its own revenue. Furthermore, we employ a flexible customer allocation mechanism to model the different customer behaviors that might arise in applications ranging from passenger airlines, to express parcel delivery, to ground (truck) freight transportation.

Unlike other models that implicitly treat all customers (e.g., passengers) equivalently by maximizing the traffic captured, in our model some customers are more valuable since they generate higher revenues (e.g., from higher fares for longer trips). We assume each competitor would receive the same revenue from a given customer, so we can focus on competition from differing network structures, rather than from differential pricing (e.g., different fares). Because the leader and follower firm will adopt different hub networks, the competition for customers is based on the relative utility of the origin-destination paths through the hub network of each firm. Our customer allocation function allocates demand between the competitors based on the relative utilities of the origin-destination paths provided by the leader and follower. This allows fractional allocations between the competitors, as well as an "all-or-nothing" allocation. Computational results highlight how optimal network design can be very sensitive to the details of the customer allocation mechanism in competitive problems, even though the amount of business captured in aggregate may be relatively insensitive to the allocation mechanism. Results also demonstrate how the leader and follower adopt different optimal strategies for designing their hub network.

Improved Algorithms for Some Competitive Location Centroid Problems on Paths Trees and Graphs

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We consider a common scenario, frequently studied in competitive location, where two competitors (providers) place their facilites (servers), and users can choose between the providers. We assume that each user has an inelastic demand, specified by a nonnegative real weight. Moreover, a user is served by a single facility and his decision about the serving facility is based only on the distances to the facilities: A user is fully served by a closest facility.

The benefit of a competitor is his market share, i.e., the total weight (demand) of the users served at his facilities. In our scenario the two providers, called the leader and the follower, sequentially place p and r identical servers, respectively. After the leader selects the locations for his p servers, the follower will determine the optimal locations for his r servers that maximize his benefit. (We explicitly assume that a user will prefer the follower only if his distance to a closest server of the follower is shorter than his distance to a closest server of the leader.) An (r, p)-centroid is a set of locations for the p servers of the leader, that will minimize the maximum benefit of the follower who can establish r servers.

In this study we discuss the (r, p)-centroid problem where the underlying metric space is a network induced by an undirected connected graph with positive edge lengths, and the nodes model the users. We present complexity results and algorithms for a variety of cases, depending on the topology of the graph and the values of r and p.

LOCATION AND TRANSPORTATION

Assessing suitability of location models for estimating origin destionation matrices from traffic counts

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The information provided by an Origin-Destination (O-D) matrix is basic for planning and managing urban transit systems. The traditional way of obtaining O-D matrices from surveys is expensive in terms of time and budget. On the other hand, estimating O-D matrices from traffic counts on links only requires a procedure of analyzing data, which are automatically captured.

The models based on entropy maximization (EM) and information minimization (IM) techniques are the most commonly used methods for the estimation of O-D matrix from traffic counts. Some researchers have shown that a data variation can affect to the EM/IM model performance and, subsequently, they consider that the accuracy and stability of those models has not been well defined yet.

This paper explores the suitability of different Location Models as approaches to be used for estimating an O-D matrix.

Location-arc routing problems: heuristic approaches and test instances

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Location-routing is a branch of locational analysis that takes into account distribution aspects. Within these problems it is easy to consider scenarios where the demand rather than being on the nodes of a network (typically a road network is assumed) is on the edges (referred in the literature as location-arc routing problems – LARP). Examples of such scenarios include locating facilities for postal delivery, garbage collection, road maintenance, winter gritting and street sweeping.

The LARP has been frequently overlooked in the literature, albeit having several real-world applications. This work presents some heuristic approaches to tackle the LARP, as well as some proposals for benchmark instances (and corresponding results). Regarding the heuristic approaches new constructive and improvement methods will be presented and used within a metaheuristic framework. Test instances were obtained from the capacitated arc routing problem (CARP) literature and adapted to address the LARP.

Location choice based on residual capacity of transport system

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In the last years important changes on urban features strongly modified the quantity and the quality of mobility system: the continuous spread of residences and activities have increased the length of trips and the use of private transport; the usual mobility habits have been changed by more complex behaviours (trip chaining). A generalized decrease of the population density of urban areas is recorded all over the world and it is associated to a generalized relevant increase in terms of private vehicle ownership and its level of use with strong impacts on environment and sustainability.

In the last years, novel efforts have been made in literature involving the study of the interaction between land-use and transport. It is possible to observe that this interaction is a complex problem, with a lot of variables, complex relationships, weak constraints and different aspects involved (from economy to social life).

Starting from these considerations, this paper deals with a new methodology developed for an integrated design models for the definition of land-use and transport system characteristics. The problem has to be approached systematically, analyzing simultaneously all its levels (macro-meso-micro) and taking into account the difference in time between actions on land-use and actions on transport systems. Such methodology identifies the land use "levels" compatible with the residual capacity of the individual elements of the transport system and consequently, contrary to the usual planning process, adapting the location of residences and activities and the intensity of such development to the characteristics of the transport systems. The model adopted is formulated as an optimization problem, directly derived from the matrix estimation problem with traffic counts, in which the objective function to be minimized is not the typical measure of distance between observed and assigned volumes but between link capacity and assigned volumes.

Capacitated vehicle routing problem with contract optimization

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In manufacturing companies, logistic activities are often outsourced to specialized companies. Generally, transportation is the service most externalized. In the literature, these actors of the supply chain are known as "third-party logistics (3PL) providers" or "logistics service providers (LSPs)". Usually, two types of managerial problems are related to logistics decisions. The strategic decisions deal with the configuration of networks: echelon, location, production, transportation and inventory problems, according to the specific configuration of the logistics networks. The operational decisions deal with scheduling, lead time, routing, truck loading problems, according to the coordination in the logistic networks. The outsourcing of logistics activities shifts location analysis in logistics networks from a strategic to an operational level. For instance, the location of warehouses is a strategic activity. When an organisation outsources its logistics activities, it selects some groupage providers from those distributed in the area. This activity is considered operational.

This paper focuses on operational decisions, providing a new formulation of the routing problem that takes into account the relationship between the manufacturer and the logistics providers, i.e. freight companies and groupage providers. We call it Capacitated Vehicle Routing Problem with Contract Optimization (CVRPCO). By outsourcing, the manufacturer has a different cost structure of freight. It is not related to travel time or distance, neither to fixed cost (insurance costs, amortization, etc.). On the contrary, costs are related to service purchasing, i.e. freights and groupage services. In the contract there are some constraints on the travel, such as the number of stops and the maximum distance between the stops. The objective is then to minimize the delivery costs of manufacturer according to the contract rules. The developed model supports the decision process in the operational activities

Two location-allocation models for the transit network timetabling problem

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The Transit Network Timetabling Problem (TNTP) aims to determine optimal timetables for each line in a transit network by establishing departure and arrival times at each station. The main objective in public transportation consists of providing an optimal service for passengers under fleet size constraints. Those users traveling later or in advance than their desired travel times, will suffer an scheduling cost which would be unavoidable unless vehicles performed departures continuously.

TNTP is related to the well known p-median problem in operations research, where the objective to be minimized is some measure of time between vehicle departures and user requests. However, costs for traveling later or before than desired times should be different so an asymmetric fitting function should be defined in order to evaluate riders disarrangements. In addition, since an inappropriate timetable could provoke a passenger deviation to another means of transportation, times windows for each traveler must be required.

This paper deals with the optimal timetable for a given number of vehicles when users differ between their desired travel times. According to different transport policies, the problem is formulated through two location-allocation models and is solved for real size instances.

Exact models and a heuristic method for a two-echelon capacitated location-routing problem

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The design of a two-echelon freight distribution system is a strategical and tactical decision problem. The aim is to define the location and the number of two kinds of capacitated facilities (platforms and satellites), the assignment of final customers to satellites and of satellites to platforms, the size of two different vehicle fleets and the related routes on the two echelons (Crainic et al. [1], [2]).

The problem has been modeled as a two-echelon capacitated location-routing problem (2E-LRP). Two models are presented. The first derives directly from three-index formulation proposed by Ambrosino and Scutellà [3] for multi-level LRP. The second one is based on multi-depot vehicle-routing formulation proposed by Dondo and Cerdà [4], which uses exclusively assignment and sequencing variables.

The problem is clearly NP-hard. The solutions provided by a commercial solver for the proposed models confirmed the need of approaching it with a heuristic method.

To this aim a Tabu Search heuristic has been proposed and implemented. It is based on the decomposition of the whole problem in four subproblems, one FLP and one VRP for each echelon. The four sub-problems are sequentially and iteratively solved and their solutions are opportunely combined in order to determine a good global solution. The heuristic is based on the expansion of two-phase iterative approach, proposed by Tuzun and Burke [5], and on nested approach of Nagy and Salhy [6], hence it can be defined as an "iterative-nested approach".

Tabu Search has been experienced on three set of small, medium and large instances and the obtained results have been compared with the results of the models and available upper bounds. Experimental results prove that proposed TS is effective in terms of quality of solutions and computation times in most of the solved instances.

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Locating flow-capturing facilities of different sizes on a railway network

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This paper presents a hierarchical version of the flow-capturing location problem which focuses on the situation to capture flows over a railway network. The original flow capturing location problem (FCLP) aims to locate a given number of facilities on a network which maximize the total flow that can obtain service along their pre-planned routes. Although various extended models of FCLP have been proposed, the problem of capturing flows over a railway network has not been paid much attention so far. To describe the situation for capturing flows over a railway network, we extend the original FCLP in two directions. First, the number of facility users for a given flow is assumed to be dependent on the accessibility of each station on the path. For example, a facility located at the origin station and the destination station is easily accessible while getting off the train in the intermediate station on the path is more cost consuming. Second, we assume that there are facilities of different sizes and the larger facility is more attractive than the smaller one and can capture more demands. People sometimes get off train to drop by an attractive large facility while a small facility is not much used on the path. The proposed problem aims to locate a given number of facilities in each size so as to maximize the total number of facility users over a network. We present an integer programming formulation of the problem and provide some optimal facility location patterns using some example networks. A Lagrangian relaxation method for our problem is also presented and results of computational experiments are reported.

A decision analysis framework for intermodal transport: Evaluating fuel price increases

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This paper presents the impact of fuel price increases on the market area of intermodal transport. Several fuel price scenarios will be analysed in order to verify the impact of possible evolution on the market share of unimodal road transport compared to intermodal transport. The LAMBIT-model (Location Analysis for Belgian Intermodal Terminals), which is a GIS-based model (Macharis and Pekin, 2009), makes it possible to analyse the different fuel price increases and to visualise the impact on the market share. Results show that the market areas rise in favour of intermodal barge/road and intermodal rail/road as the fuel price increases with 10% (low price case), 50% (business as usual case) and 90% (high price case). The recent attitude of European policy makers is the idea that transportation costs should reflect the true impacts to environment and society expressed in monetary terms, so called 'internalisation of external costs'. Based on this idea and the fact that fuel prices boomed in 2008 an important question has risen: "What will be the impact of the fuel price scenarios on the internalisation of external costs?" This effect is also examined using the LAMBIT-model. In this respect, the costs of the different transport modes are internalised based on current market prices and the fuel price scenarios are taken into account.

LOCATION WITH UNCERTAINTY

Building Probabilistic Covering Models using α-reliability and local busyness estimates

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A key Emergency Medical System (EMS) planning problem involves the efficient deployment of ambulance crews across a region. In 1989 ReVelle and Hogan introduced an approach to estimate the busyness of local-based crews, thereby creating an approach to estimate the frequency of service coverage. This concept along with their objective of maximizing α-reliable coverage has been used in virtually all probabilistic-based coverage models since their introduction. In this paper, we discuss issues related to the use of these two modeling constructs in practice and arrive at a somewhat surprising conclusion based upon results generated by a simulation model designed to represent a simple system that incorporates the elements under which local busyness estimates are calculated. We show that a hybrid model can be formulated which outperforms earlier proposed constructs.

Stochastic Set Packing Location Problems

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In this work a stochastic version of set packing location problems is studied via scenario analysis, by using a one-stage recourse approach to deal with the uncertain coefficients of the objective function. The problem consists of maximizing a composite function of the expected value minus the weighted risk of obtaining a scenario whose value is worse than a given threshold. The splitting variable representation is decomposed by dualizing the nonanticipativity constraints that link the deterministic problems with a 0-1 knapsack problem for each scenario under consideration. As a result a (structured) larger pure 0-1 model is created. Several procedures for obtaining good feasible solutions are presented, as well as a preprocessing approach for fixing variables. The Lagrange multipliers updating is performed by using the Volume Algorithm. Computational experience is reported for a broad variety of instances, it shows that the new approach usually outperforms a state-of-the-art optimization engine producing a comparable optimality gap with smaller (several orders of magnitude) computing time.

A Study of Robustness for the Maximum Capture Problem

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The need for robust solutions has always been there and researchers have been working to find different means and methods to deal with the uncertainty in the model parameters. The popular approaches found in the literature in dealing with the robustness will be presented. A few approaches to obtain the robust solutions based on the overall behaviour, frequency based and the worst case behaviour methods are proposed and applied on a competitive location model. The model considered is the original MAXCAP model where the objective is to maximize the demand capture while finding p facilities given that there are already q facilities existing in the spatial market under consideration. The results obtained by the proposed approaches are compared with the optimal solutions and their performances are discussed.

Robust Solutions for Location Problems with Uncertainties

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We consider location problems where uncertainty not only occurs in the demand and position of the existing facilities, i.e., in the location objective, but also in the constraints of the problem like, for example, the size and location of the feasible region and/or the occurrence and position of barriers to travel.

The trade-off between the cost of a solution on one hand and its robustness with respect to the uncertain data on the other hand is analyzed. Different models to cope with uncertainty like minmax regret models (to handle uncertain demands) and recent robustness concepts like recoverable robustness (to handle uncertainty in the constraints) are discussed.

The Facility Location Problem with Bernoulli Demands: Exact Solution

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This work is concerned with the solution of the Capacitated Facility Location Problem with Bernoulli Demands (CFLPBD). In this discrete facility location problem the actual set of customers is not fixed beforehand. Instead, a larger set of potential customers is known. This is modeled by representing the demands of the potential customers with independent Bernoulli random variables. The problem is formulated as a two-stage stochastic program where the set of sites where facilities will be established, and the assignment of potential customers to those facilities are decided a priori, taking into account that no plant can be opened unless a minimum number of potential customers are assigned to it. Once the actual set of customers having demand is known, they are served from the plants where they have been assigned, unless service capacities of the facilities are exceeded. In this case, a penalty is paid for the unsatisfied request. The location of facilities and assignment of customers is chosen so that the fixed costs plus the expected value of the total service cost and penalties is minimized.

Although this is not a problem with simple recourse, a closed form is derived for the recourse function. Moreover, when it is assumed that all the customers have the same probability of requesting a service, this closed form of the recourse function allows to reformulate the deterministic equivalent problem with only a slight increase in the number of variables. Using this formulation, medium size instances of the problem can be optimally solved in small times. We use estimations of the expected value of perfect information to study the impact it has on the solution to explicitly consider the stochasticity of the problem. To this end, a series of computational experiments have been carried out.

A multi-stage stochastic supply chain network design problem with financial decisions and risk management

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We consider a multi-period supply network design problem. The decisions to be made involve the location of facilities, the flow of commodities and the amount of money spent in alternative investments (loans are considered as special investments, too). Costumers' demand and interest rates are assumed to be uncertain and are described by discrete scenarios. The problem is formulated as a multi-stage stochastic mixed-integer linear-programming problem. The objective combines three weighted goals. The profit of our decisions has to be maximized, a service level measures the proportion of satisfied demand and a risk measure punishes scenarios, where a target return on investment is not reached. In comparison to most multi-stage stochastic problems which have been considered so far, all variables in all periods interact because of the considered service level and downside risk. This makes the typical separation into successive periods and recursive solution approaches useless for this problem. However, we can show that this type of problems is still manageable. Computational tests using randomly generated data are presented and compared to the results of an equivalent pure deterministic model. The value of the stochastic problem, as well as the acceptable computation times, shows that stochastic programming is appropriate for this type of problems.

NETWORK LOCATION

Robust Mean Absolute Deviation Problems on Tree Networks

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Equity in Location Theory is usually modelled by means of objective functions wich quantify the level of inequality of the distribution of distances. One of most frequently considered inequality objective functions is the Mean Absolute Deviation, which measures the average absolute deviation from the set of customers to the facility. The corresponding single optimization problem with this measure have already been studied and solved in polynomial time in both cyclic and tree networks with deterministic parameters. However, in practice the edge lengths and vertex weights are very often not deterministic, and Robust Optimization is one of approaches which have been proposed for dealing with such situations. The most common criteria applied in robustness literature are the Minmax (or the absolute robust) criterion, which seeks to minimize the largest objective value, and the Minmax-Regret (or the robust deviation) criterion, which minimizes the largest feasible deviation from the best objective value.

In this work, we apply such robust criteria to the Mean Absolute Deviation objective to formulate the respective single optimization problems on a tree network where the vertex weights are linear functions of time. For each of the robust problems thus obtained, we study the set of solutions, propose an exact algorithm and discuss its complexity.

Models for optimal content location in CDN networks

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A CDN (Content Distribution Network) is an architecture for telecommunication networks where the content requested by the clients is distributed as efficiently as possible into the network in order and to reduce network resources consumption and to speed-up access times to the data [7]. A CDN is an alternative to the classical centralized "client/server" architecture. One of the main factor in deciding an optimal CDN architecture is to find the right balance between centralized and fully decentralized solutions, typically based on the ratio between storage and transmission costs.

Location models are hence an ideal tool to deal with CDN design problems, the basic decision being "where to locate the servers?". Another way to decentralize the content is to use caches. A cache is an equipment with a storage capacity, deployed somewhere between the server and the client, and storing the content most recently requested by its clients. In a cache, the content is dynamically distributed according to the clients on line requests. This type of equipment hence adds another dimension to the overall design problem, namely "where to locate the caches?" and of course, the location of both types of equipments must be addressed in a same model.

Location models have already been extensively used for the design and the management of telecommunication networks [3] [9]. The location problem where the storage is static (its content does not vary over time) and all the clients are interested in the same content, has been quite often studied [2] [4] [5] [8]. Problems where the content is distributed in an heterogeneous fashion among the servers or where the storage equipment has only a limited probability to provide the content (such as a cache) have been much less investigated [1] [6]. We propose Mixed-Integer Programming models and resolution methods to address some of these new problems.

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Formulations for the Center Facility Location Network Design Problem with Budget Constraint

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This work presents the Center Facility Location Network Design Problem with Budget Constraint. It is a new model for integrated facility location and network design, which simultaneously considers the location of service facilities and the design of its underlying transportation network. The problem also includes a budget constraint on the overall cost for the location of facilities plus the construction of the network. The objective is to minimize the maximum distance between any demand point and its allocated service facility. The evaluation of the objective is involved as the paths connecting the nodes and their allocated facilities must be identified. Indeed, such paths relate the selected arcs, the selected hubs and the allocation of non-hubs to hubs.

The complexity of the problem is established and two alternative integer programming formulations are presented and compared. A multicommodity-based formulation is clearly outperformed by a smaller formulation that exploits the structure of the problem. This smaller formulation is taken as basis for further improvements and is successively strengthened by introducing further classes of valid inequalities. The effect of employing tight upper bounds to reinforce some constraints of the formulation and to derive simple reduction tests is discussed. Numerical results of a series of computational experiments for instances on up to 100 nodes are presented and analyzed

On some variants of the shortest path tour problem as facility location problem

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The shortest path tour problem (SPTP) consists of finding a shortest path from a given origin node s to a given destination node d in a directed graph with nonnegative arc lengths with the constraint that the optimal path P should successively pass through at least one node from given node subsets T_1 , T_2 , . . . , T_N , where $\cap_{k=1}^{N} T_k = 0$.
It has been recently shown that the SPTP belongs to the complexity class P. Nevertheless, in this talk we will discuss on some variants of the SPTP and we will prove that they are special facility location problems.

Evacuation Planning and Locational Analysis (EvacLoc)

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In the planning of regional evacuations the location of facilities may have a rather dramatic influence on the evacuation time, i.e. the necessary time for the last evacuee to leave the region. In order to show this influence we model evacuation planning as a (dynamic) network flow problem, where the network mirrors the evacuation region, and where arc capacities and transit times are related to the number of evacuees which can pass through parts of the network and their walking speed, respectively.

Optimal dynamic network flows, in particular so-called quickest flows, provide lower bounds for the evacuation time. In EvacLoc we consider the impact of locating facilities – like souvenir booths, hot-dog carts, but also emergency or police units– on this lower bound. Since this location process decreases capacities and might increase transit times, a bad location decision will increase the evacuation time considerably. The proposed model of measuring location decisions by the objective value of a network flow problem is an example of a combination of network flow and location problems (FlowLoc), which which includes the location of sources in a flow network as another example (see presentation of Lara Turner at this conference). In the talk we propose our EvacLoc model for finding optimal locations, address complexity issues of the resulting FlowLoc problem and present some numerical results for a case study of evacuating the region of the Fritz-Walter football stadium in Kaiserslautern, Germany, which is part of the evacuation project REPKA (Regional Evacuation: Planning, Control and Adaptation).

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The Multi-Facility Median Problem With Pos/Neg Weights on General Graphs

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In this talk we discuss the multi-facility median location problem on networks with positive and negative weights. As the finite dominating set for the single facility problem does not carry over to the multi-facility problem, we derive a new finite dominating set using a geometric approach. To solve the problem, we present a straight forward algorithm. Moreover, for the problem with just two new facilities, we show how to obtain a more effcient solution procedure by using planar arrangements. We present computational results to underline the effciency of the improved algorithm and to test some approximations which are based on a reduced candidate set. In addition, we discuss the problem on trees.

A polynomial algorithm for the multi-objective bottleneck network problem with one MinSum objective function

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The paper presents multi-objective combinatorial optimization problems in graphs where at most one objective is a MinSum function and the other objectives are of the bottleneck type. Applications in the area of locational analysis are given. A polynomial algorithm is developed which generates a minimal complete set of Pareto-optimal solutions. Optimality proofs are given.

A computational study on the duty generation for the Multi-Depot Bus Driver Scheduling Problem

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The bus driver scheduling problem asks for assigning a given set of trips to driver duties in order to minimize the total fixed and variable costs. In the multi-depot version of the problem drivers are located at several scattered depots. Most of the successful approaches reported in the literature model the problem as a set partitioning problem with side constraints and solve its linear relaxation by column generation. The pricing problem decomposes into the generation of a duty for each depot and a feasible duty is obtained by solving a resource constrained shortest path problem. Integer solutions can therefore be obtained either by branch-and-price or by heuristic variable fixing. Since a duty for each depot has to be computed at each iteration of the column generation, the computational cost considerably increases as the number of depots grows, e.g., in extra urban bus transit systems or in cases of global company reorganization when tactical scheduling decisions might be taken together with strategic location decisions, i.e., dismissing existing depots and/or opening new ones. When the number of depots is very large, an attempt to reduce the number of generated columns, and hence the CPU time, consists to iteratively solve the linear relaxation of a fictitious-single-depot bus driver scheduling problem and then optimally assign duties to depots. In this work we compare the performance of the two alternative approaches.

INVITED SPEAKERS

Applications of Meta-Heuristics to Traffic Engineering in IP Networks

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Intra-domain routing protocols are based on Shortest Path First (SPF) routing, where shortest paths are calculated between each pair of nodes (routers) using pre-assigned link weights. These link weights can be modified by network administrators in accordance with the routing policies of the network operator.

The operator's objective is usually to minimize traffic congestion or minimize total routing cost subject to the traffic demands and the protocol constraints. However, determining a link weights combination that best suits the network operator's requirements is a difficult task.

This talk will survey meta-heuristic approaches to traffic engineering, focusing on local search approaches and extensions to the basic problem taking into account changing demands and robustness issues with respect to network failures.

Vehicle Routing in Practice

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Solving the Vehicle Routing Problem (VRP) is a key to efficiency in transportation and supply chain management. The VRP is a computationally hard problem that comes in many guises. The VRP literature contains thousands of papers, and VRP research is regarded as one of the great successes of OR. In industry and the public sector, vehicle routing tools provide substantial savings every day. An industry of routing tool vendors has emerged.

Exact optimization methods of today cannot consistently solve VRP instances with more than 100 customers in reasonable time, which is generally a small number in real-life applications. For industrial problem sizes, and if one aims at solving a variety of VRP applications, approximative methods is the only viable approach.

In this talk, a motivation and introduction to the VRP will be given. We then describe how industrial requirements motivate extensions to the basic, rather idealized VRP models that have received most attention in the research community, and how such extensions can be made. At SINTEF, industrial variants of the VRP have been studied since 1995. Our efforts have led to the development of generic VRP solver that has been commercialized. As an illustration, a description of the underlying, rich VRP model and the selected uniform algorithmic approach, which is based on metaheuristics, is given. Examples of applications will be presented, along with results from computational experiments.

In many application areas, there is still a gap between industrial requirements and cutting edge VRP methods, particularly for large-scale problems and complex, rich VRP variants. Examples from ongoing projects at SINTEF will be given. We point to future trends and important issues in further VRP research, including the use of parallel and heterogeneous computing.

Author Index

The book contains the abstracts of the presentations at the XVIII Meeting of European Working Group on Locational Analysis (EWGLA), held in Naples, April 28-30, 2010. The EWGLA meetings gather Operations Research practitioners to share experiences in the field of Locational Analysis. For this reason the book provides a significant overview of current researches in the field of the Locational Analysis.

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