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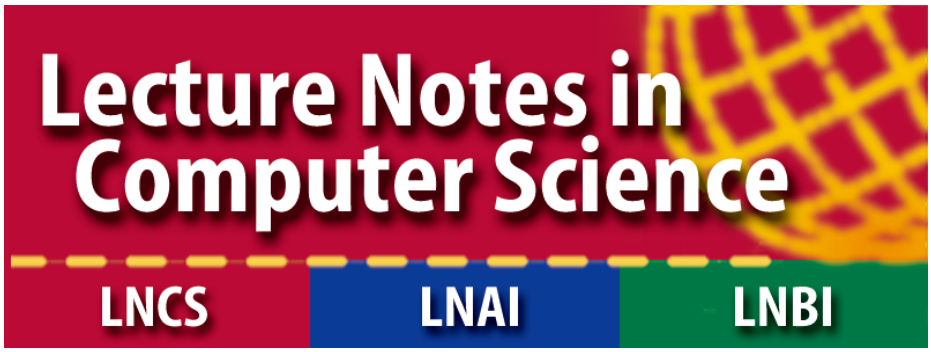
BOOK OF ABSTRACTS

Organizing Institutions



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Anand Subramanian	*Universidade Federal da Paraíba, Brazil*
Bruno Vieira	*Universitat Pompeu Fabra*

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Maritime Logistics I

Wednesday, September 21, 15:30- 17:00

Chair: Dario Pacino

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Wednesday, September 21, 15:30-17:00; Session: Maritime Logistics I

Port Rail Shunting Re-scheduling Problem

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Abstract. This work deals with the Port Rail Shunting Re-Scheduling Problem (PRSRP), a problem arising in the port area where import/export trains are daily scheduled for their transfer from a railway station to the maritime terminals and vice versa. Each train requires to perform a set of activities. Usually, the shunting manager schedules the activities in such a way to respect the time limits imposed by the railway network schedule and by the ships, and the limits due to the finite available resources. This scheduling problem, known as Port Rail Shunting Scheduling Problem (PRSSP), has been investigated in [1] and [2]. Furthermore, the shunting manager has to re-schedule the planned activities on a daily basis when unpredictable events occur. In the current work, we model and solve the re-scheduling of the shunting operations when different events happen.

For solving this problem, we have modified the optimization model proposed in [2] for PRSSP. The new one is a flow model based on an operations-time-space network representing the zones inside the port. In each zone, one type of operation is performed on trains. The maritime terminals and the rail station can be either the origin or the destination of the trains, and thus of the flow in the network.

The nodes of the network, representing the zones and the operations to execute on trains, are replicated for each time interval of the considered schedule horizon. Vertical arcs represent

the transfer of a train from one zone to another one, i.e., the end of a given operation in t and the simultaneous beginning of the following required operation. The horizontal arcs represent the time spent by a train in a given zone for the execution of the required operation. Other than the classical constraints of the flow model, we have constraints related to the capacity of tracks, the limit on the number of simultaneous shunting operations, the required duration of each operation.
The computational tests for validating the proposed model will be presented. The tests are based on randomly generated instances derived from real cases. The unpredictable events that may happen include the delay of a train, a variation of the terminal availability timing, a variation in the duration of a shunting operation, an extracurricular train to be included in the schedule, and the suppression of a train. From first results, thanks to the proposed model, we are able to solve up to optimality in very short time all the tested instances and the quality of the obtained solutions seems good. Results related to different scenarios will be presented.

Keywords: Port Rail Shunting Operations, Rail Shunting Re-scheduling Problem, Mixed-Integer Linear Programming Model

References:

Ambrosino, D., Asta, V. 2019. Intermodality and Rail Transport: Focus on Port Rail Shunting Operations. Advances in Optimization and Decision Science for Society, Services and Enterprises (Springer), 351–366.

Ambrosino, D., Asta, V., & Crainic, T. G. 2022. Port Rail Shunting Scheduling Problem. Transportation Research Part E, submitted.

Wednesday, September 21, 15:30-17:00; Session: Maritime Logistics I

A Representative Formulation of the Container Vessel Stowage Problem and a new Non-Hierarchical LNS Solution Approach

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Abstract. Global containerized trade resulted in 149 million twenty-foot equivalent units in 2020 and this number grows about 4% on a yearly basis [1]. Considering the volume of shipped goods, research resulting in improvements of the stowage plans can yield remarkable economic and CO2 emissions savings. With almost 10 years of experience working closely with several shipping companies we realized that the container vessel stowage problem is poorly understood in the literature and lacking a standardized definition that researchers can refer to. This work contributes a realistic description of the problem, matched with an extensive benchmark suite based on real-life data.

The container vessel stowage problem is complex and has several constraints and objectives interacting with each other. While creating a standard description, it is crucial to carefully choose which objectives and constraints to consider to fully capture the nature of the problem without overly complicating or simplifying the problem. Besides basic stack capacity limits and stowage rules, the constraints we chose include hydrostatic limits, minimum crane intensity, lashing forces using simplified moment-based calculations and block stowage. The objective function is a mix of the number of containers stowed on the vessel and the amount of free space left. More details on the selection of key aspects will be presented.

The benchmark suite comprises different types of vessels and port call lists to challenge different aspects of the container vessel stowage problem: finding space for large amounts of refrigerated containers, heavy containers, or dangerous cargo, etc. The benchmark suite contains 4 vessel profiles of different sizes, each vessel has 5 different rotations assigned and each rotation includes at least 25 load lists based on real-life data, resulting in around 500 different problem instances.
A large neighborhood search (LNS) was implemented working with the Sealytix company to provide initial feasible solutions for the described benchmark suite. The academic research on stowage planning often favors hierarchical decomposed algorithms where the container ship stowage problem is divided into 2 or more subproblems that are solved separately [2]. Our experience building a 4-phase algorithm for use in the industry is that such multi-phase algorithms with different representations and methods used in each phase often break down in practice. They are expensive to maintain, and it is challenging to ensure that the problems solved by each phase are aligned. Our non-hierarchical LNS approach scales well with medium-size vessels, but future research is needed for bigger vessels with longer port call lists.

Keywords: Stowage Planning, Optimization, Benchmark, LNS

References:

On Trade, U.N.C., Development: Review of maritime transport 2020. United Nations, 1 edn. (2021)

Pacino, D., Delgado, A., Jensen, R. M., & Bebbington, T. (2011). Fast generation of near-optimal plans for eco-efficient stowage of large container vessels. In ICCL'11: LNCS 6971. pp. 286–301.

Wednesday, September 21, 15:30-17:00; Session: Maritime Logistics I

The Dynamic RORO Stowage Planning Problem

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Abstract. The shipping industry's greenhouse gas emission reduction has received significant focus over the past years. One of the research areas is that of stowage planning for RORO vessels. Efficient stowage plans are necessary to reduce the turnaround time for vessels in a port. Reducing turnaround time results in prolonged sailing time, allowing vessels to reduce fuel consumption through slow steaming. When RORO vessels have calls at several ports, they handle cargo as an approximate FILO queue. Therefore, cargo can potentially become blocked when stowing cargo for later ports, behind cargo with an earlier discharge port. Planning the cargo assignment onboard the vessels also requires considering the arrival time of cargo at the port. Recent research assumes that all freight is available for stowage when the RORO vessels arrive at the port. However, this is not always the case. The unique elements of scheduling and generation of loading/discharge paths are therefore of academic interest. We propose a novel mathematical model with a weighted objective function that minimizes the relationship between the fuel consumption cost and the revenue gained from shipping cargo. The model schedules the cargo loading sequence to reduce time spent handling and re-handling cargo at each port. The problem is studied for a single deck layout for a vessel calling multiple ports. Results of the mathematical model and accompanying metaheuristic will be presented.

Keywords: Stowage Planning, Cargo Assignment, Mathematical Model, Metaheuristic

Sustainability I

Wednesday, September 21, 15:30-17:00

Chair: Giacomo Lanza

1 **Considering Resilience in a Green Location-Routing Problem.*** *Bruna Figueiredo and Rui Borges Lopes*

2 **A Carbon-Aware Planning Framework for Production Scheduling in Mining.** *Nurul Asyikeen Azhar, Aldy Gunawan, Shih-Fen Cheng and Erwin Leonardi*

3 **The Green Sequencing and Routing Problem.** *Giacomo Lanza, Mauro Passacantando and Maria Grazia Scutellà*

Wednesday, September 21, 15:30-17:00; Session: Sustainability I

Considering Resilience in a Green Location-Routing Problem

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Abstract. Recently, the concept of green logistics has been increasing in interest. Efforts are being made to consider environmental externalities in the planning and execution of the associated activities. However, in the current globalized environment, companies face significant risk and uncertainty. Therefore, when companies start to integrate the concept of sustainability into their practices, they must be able to make decisions that are not only sustainable but also resilient. This requires decision-support tools, from the operational to the strategic levels, that are also capable to address possible disruptions or disturbances.

The location-routing problem (LRP) is a class of problems that handles, in an integrated way, three major decisions arising in logistics: the selection of facilities; the assignment of demand points to the facilities, and the design of vehicle routes that must serve these points. The Green LRP is an extension of this problem that considers fuel consumption and carbon dioxide emissions, beyond the operating costs.

This work tries to incorporate the concepts of sustainability and resilience in a multi-objective LRP, exploring new objective functions and analyzing their impact on economic goals. The focus is on the Green LRP variant, with capacity constraints in facilities and vehicles. Thus, in addition to the total cost minimization objective, the minimization of carbon dioxide emissions resulting from the distribution activity is also considered. The emissions are estimated using a fuel consumption model that is dependent, among other factors, on the speed and load carried by the vehicle in each arc. Furthermore, the resilience of the system to disruptive

events is modeled as a third objective, quantified according to the number of alternative paths connecting the nodes in the distribution network. This objective aims to find solutions with increased flexibility, by allowing a quick adjustment of distribution routes when facing disruptive events.
Based on real data derived from a distribution company in the Aveiro region in Portugal, two instances of the proposed problem are solved using CPLEX. One of the instances is composed of 23 customers and 5 depots, while the other has 18 customers and 4 depots. The results are analyzed, and some preliminary conclusions are drawn.

Keywords: Green Location-Routing Problem, Mixed-Integer Linear Programming, Resilience, Sustainability

Wednesday, September 21, 15:30-17:00; Session: Sustainability I

A Carbon-Aware Planning Framework for Production Scheduling in Mining

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Abstract. Managing the flow of excavated materials from a mine pit and the subsequent processing steps is the logistical challenge in mining. Mine planning needs to consider various geometric and resource constraints while maximizing the net present value (NPV) of profits over a long horizon. This mine planning problem has been modelled and solved as a precedence constrained production scheduling problem (PCPSP) using heuristics, due to its NP-hardness. However, the recent push for sustainable and carbon-aware mining practices calls for new planning approaches. In this paper, we propose an efficient temporally decomposed greedy Lagrangian relaxation (TDGLR) approach to maximize profits while observing the stipulated carbon emission limit per year. With a collection of real-world-inspired mining datasets, we demonstrate how we generate approximated Pareto fronts for planners. Using this approach, they can choose mine plans that maximize profits while observing the given carbon emission target. The TDGLR was compared against a Mixed-Integer Programming (MIP) model to solve a real mine dataset with the gaps not exceeding 0.3178% and averaging 0.015%. For larger instances, MIP cannot even generate feasible solutions.

Keywords: Operations Research and Management, Resource Capacity Planning, Lagrangian Relaxation, Sustainability

Wednesday, September 21, 15:30-17:00; Session: Sustainability I

The Green Sequencing and Routing Problem

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Abstract. The paper deals with a sequencing and routing problem originated by a real-world application context. The problem consists in defining the best sequence of locations to visit within a warehouse for the storage and/or retrieval of a given set of items during a specified time horizon, by considering some specific requirements and operating policies which are typical of the kind of warehouse under study. A fleet composed of both electric (i.e., equipped with a lithium-ion battery) and conventional (i.e., with internal combustion engine) forklifts is considered. We model the problem in terms of constrained multicommodity flows on a space-time network, and we extend a matheuristic approach proposed for the case of only conventional vehicles. Preliminary computational results are also presented.

Keywords: Green Logistics, Warehouse Management, Matheuristic

Supply Chain I

Wednesday, September 21, 15:30-17:00

Chair: Luciana Pessoa

1 **A Framework on Centralised to Decentralised Logistics Control Structures applied in two Case Studies.** *Meike Hopman, Ruben Fransen, Irene Zubin and Jaco Meijeren*

2 **Risk-Aware Procurement Optimization in a Global Technology Supply Chain.** *Jonathan Chase, Jingfeng Yang and Hoong Chuin Lau*

3 **The Effects of Disruptions in Global Trade on Transport Operations in Supply Chains.*** *Joachim R. Daduna*

Wednesday, September 21, 15:30-17:00; Session: Supply Chain I

A Framework on Centralised to Decentralised Logistics Control Structures applied in two Case Studies

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Abstract. Developments on digitalisation and automation in transport and logistics create new possibilities in the organisation of supply chains. New technologies can disrupt existing control structures, establish new forms of control and improve the efficiency and flexibility of operations. This paper provides a framework to analyse the trade-offs and conditions that best apply to each control structure from centralised to decentralised. A centralised control structure is characterised by one party (control tower) that collects and analyses data to come to optimal operational decisions on a system level. In opposition, a decentralised control structure is characterised by each unit in the logistics chain taking independent decisions (self-organisation) based on local intelligence and autonomy. A 2x2 control structure matrix is created, with each corner defining a different type of logistics control structure. The framework is then applied in two practical case studies in which simulation models are developed to show the impact of different logistics control structures. Results show the effects of different control structures in one supply chain and under which circumstances and for which type of logistics chain, each logistics control structure is most suitable.

Keywords: Centralised or Decentralised Organisation, Container Logistics, Multi-Agent Simulation, Self-Organising Logistics (SOL), Supply Chain Management

Wednesday, September 21, 15:30-17:00; Session: Supply Chain I

Risk-Aware Procurement Optimization in a Global Technology Supply Chain

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Abstract. Supply chain disruption, from 'Black Swan' events like the COVID-19 pandemic or the Russian invasion of Ukraine, to more ordinary issues, such as labour disputes and adverse weather conditions, can result in delays, missed orders, and financial loss for companies that deliver products globally. Developing a risk-tolerant procurement strategy that anticipates the logistical problems incurred by disruption involves both accurate quantification of risk and cost-effective decision-making. We develop a supplier-focused risk evaluation metric that constrains a procurement optimization model for a global technology company. Our solution offers practical risk tolerance and cost-effectiveness, accounting for a range of constraints that realistically reflect the way the company's procurement planners operate.

Keywords: Supply Chain, Risk Tolerance, Risk Analysis, Procurement Optimization

Wednesday, September 21, 15:30-17:00; Session: Supply Chain I

The Effects of Disruptions in Global Trade on Transport Operations in Supply Chains

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Abstract. In the current discussions and also in many publications, Covid 19 pandemic and Russia's invasion and war against Ukraine as another step for a revival of the former Soviet Union are referred to as the main cause of many disruptions in international supply chains (SC). However, if one looks at the developments of international SC over a somewhat longer period, doubts seem to be raised in this respect. Risks in global SC have existed for many years and have not only been underestimated but also largely ignored. Deglobalization in connection with increasing unilateralism, protectionist tendencies and regionalization are obvious for many years, together with a rising re-shoring, and a stronger orientation towards stability, security and resiliency. The influences of the decarbonization of energy production and the disruptive effects of additive manufacturing (AM) in many fields of industry are known for years. From AM results an increase in spatially dislocated manufacturing with local and small-scale structures as well as an on-demand orientation. Various remarks that the changes due to AM will make emerging and developing countries the global losers is wrong. However, these changes, some of which have far-reaching disruptive effects, are also of great interest in a positive sense for emerging and developing countries, since the structural changes in the economic framework can offer new opportunities for a national development.

Other developments, such as the increasing sustainability discussions as well as also evolving changes in the settlement structures appear as a result from urban farming. Furthermore, initial approaches of urban re-industrialization in the case of clean production in connection with a decrease of the spatial segregation of living and working as propagated in the Carter of Athens from

1932 have been neglected significantly until to date. As the different developments show, it can be assumed that there will be a considerable decline in global transport volumes in the coming years, especially with regard to sea transport (in the sector of bulk goods and container transport). Transport flows will show a stronger spatial distribution due to structural changes in the global economy. The emerging changes in SC, in particular the decline and dislocation in international trade structures, will lead to an increased competition between transport chains.
The disruptions that have occurred have caused a shift in thinking, especially on the political side. The focus is no longer on efficient and cost-effective processes, but more on national supply security, which is increasingly important. Added to this are sustainability considerations, e.g. with regard to better use and recycle raw materials, as well as changes in product design and in the purchasing behavior of customers. We cannot estimate at this time the developments being addressed with their consequences, but we must begin to have an intensive discussion in this context.

Keywords: Global Supply Chains, Disruptive Developments, Changing Transport Processes

PLENARY SESSION I

Chair: Jésica de Armas

Coordinating and Planning Post-Disaster Health Care Services for Chronic Hemodialysis Patients

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Abstract. While disasters affect the lives of millions of people throughout the world each year, their impact on communities with existing vulnerabilities, such as patients with chronic health conditions (e.g., diabetes, heart and kidney diseases), can be highly severe. For instance, chronic hemodialysis patients, which must receive regular treatments every week in a clinic, are at significant health risk after a disaster if their treatments cannot be timely and sufficiently provided. It is challenging for decision makers (e.g., public health authorities, Renal Disaster Relief Task Force, health care professionals) to coordinate and plan the delivery of post-disaster services to these vulnerable groups in the chaotic post-disaster environment under significantly reduced dialysis capacity and increased demands. In an ongoing project, we aim to develop effective decision support tools to support effective planning and coordination of hemodialysis services for chronic patients after a disaster. In my talk, I will first discuss the needs of patients with chronic conditions after a disaster, and then present mathematical models and solution methods for three problems, which involve resource allocation, scheduling, and logistics decisions. Motivated by our collaboration with practitioners, the first problem addresses the decisions of central coordinators to assign patients to available facilities and schedule

their hemodialysis sessions. Secondly, we focus on the patient transportation and treatment scheduling decisions of a hemodialysis clinic in the aftermath of an earthquake under travel time uncertainty due to damaged road infrastructure. Finally, the third problem focuses on creating an alliance network among hemodialysis service providers to support post-disaster coordination. I will present case studies that show the benefits of the proposed approaches.

Maritime Logistics II

Thursday, September 22, 9:00-10:30

Chair: Dario Pacino

1 **A Linear Time Algorithm for Optimal QuayCrane Scheduling.** *Mathias Offerlin Herup, Gustav Christian Wichmann Thiesgaard, Jaike van Twiller and Rune Møller Jensen*

2 **Hybrid Berth Allocation for Bulk Ports with Unavailability and Stock Level Constraints.** *Xiaohuan Lyu and Frederik Schulte*

3 **The Continuous Multi-port Berth Allocation Problem with Speed Optimization.** *Bernardo Martin-Iradi, Dario Pacino and Stefan Ropke*

4 **A Self-Adaptive Hybrid Search Technique with its Application to the Quadratic Semi-Assignment, and Berth Allocation Problems.** *Mehrdad Amirghasemi, Marcella Bernardo Papini and Stefan Voß*

Thursday, September 22, 9:00-10:30; Session: Maritime Logistics II

A Linear Time Algorithm for Optimal Quay Crane Scheduling

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Abstract. This paper studies the Quay Crane Scheduling Problem (QCSP). The QCSP determines how a number of quay cranes should be scheduled in order to service a vessel with minimum makespan. Previous work considers the QCSP to be a combinatorially hard problem. For that reason, the focus has been on developing efficient heuristics. Our study shows, however, that the QCSP is tractable in the realistic setting, where quay cranes can share the workload of bays. We introduce a novel linear time algorithm that solves the QCSP and proves its correctness.

Keywords: Quay Crane Scheduling, Container Terminals, Computational Complexity

Thursday, September 22, 9:00-10:30; Session: Maritime Logistics II

Hybrid Berth Allocation for Bulk Ports with Unavailability and Stock Level Constraints

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Abstract. Berth allocation is fundamental to port-related operations in maritime shipping. Port managers have to deal with the increasing demands either by expanding the terminals or by improving efficiency to maintain competitiveness. Port expansion is a long-term project, and it requires much capital investment. Thus, the question of how to enhance the efficiency of berth allocation has received much research interest. Research on the Berth Allocation Problem (BAP) in container ports is quite advanced. However, only limited research focuses on BAP in bulk ports, although some similarities exist. Contributing to Operations Research on the BAP, this paper develops a hybrid BAP mixed-integer optimization model dedicated to bulk ports. In addition to considering the handling characteristics of bulk ports, we also incorporate more practical factors such as unavailability and stock levels. The objective of the proposed model is to minimize the demurrage fee for all vessels under consideration of unavailability and stock constraints. We use the commercial software CPLEX to obtain the optimal solutions for a set of instances, explicitly considering the situation of multiple cargo types on one vessel. The results show the effectiveness of the proposed model and can provide decision-making support for bulk port managers.

Keywords: Berth Allocation Problem, Bulk Ports, Unavailability, Stock Levels, Optimization, Mixed-Integer Program

Thursday, September 22, 9:00-10:30; Session: Maritime Logistics II

The Continuous Multi-Port Berth Allocation Problem with Speed Optimization

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Abstract. We study the multi-port continuous berth allocation problem with speed optimization. This problem integrates vessel scheduling with berth allocation at multiple terminals in a collaborative setting. We propose a graph-based formulation and a branch-and-price method to solve the problem. The results show that the branch-and-price procedure outperforms the baseline solver. In our computational study, we highlight the trade-off between solution quality and computational complexity as a function of the segment length used to model a continuous quay.

Keywords: Transportation, Maritime Logistics, Container Terminal, Exact Methods

Thursday, September 22, 9:00-10:30; Session: Maritime Logistics II

A Self-Adaptive Hybrid Search Technique with its Application to the Quadratic Semi-Assignment and Berth Allocation Problems

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Abstract. Both the quadratic semi-assignment problem and the berth allocation problem are about assigning items (vessels) to sets (berths) and have various applications from floor layout planning to schedule synchronization in public transit networks, and maritime logistics. Considering the similarities of these two problems, this paper presents a hybrid solution strategy in which an adaptive improvement technique is embedded into a genetic algorithm. This hybrid has six components, namely (i) an integration of a best-improvement and a regret-based construction method, (ii) an integration of regret-based and ranked-based crossover operators, (iii) a local search technique, (iv) a perturbation mechanism, (v) a facilitating hash-based method for having quick access to the worst solution in the pool to replace it, and (vi) a self-adaptive module managing the interaction of other components. For the purpose of self-adaptivity, all important parameters of the procedure are embedded in the employed genomes and evolve while the procedure is executed. In addition to the hybrid strategy, a simple branch-and-bound brute force method is also implemented to find the optimal solution for small instances. Computational experiments show that the presented procedure finds the optimal solution for randomly generated 20x5 instances in less than a millisecond. These instances are the largest instances for which we could find optimal solutions within several hours time.

Keywords: Quadratic Semi-Assignment, Berth Allocation, Genetic Algorithm, Metaheuristics, Maritime Logistics

Sustainability II

Thursday, September 22, 9:00-10:30

Chair: Stefan Voß

1 **Locating Hydrogen Production in Norway Under Uncertainty.** *Šárka Štádlerová, Trygve Magnus Aglen, Andreas Hofstad and Peter Schütz*

2 **How can a Refrigerated Warehouse be used to store Energy?** *Marco Repke, Ann-Kathrin Lange and Carsten Eckert*

3 **A Practical Solution Approach for the Large-Scale Multi-Depot Vehicle Routing Problem.*** *Duc Minh Vu, Emrah Demir, Vasco Sanchez, Rodrigues and Aris Syntetos*

4 **Hinterland Intermodal Transport Routing as an Added-Value Tool for Port Community Systems: a Colombian Case Study.** *Adriana Moros-Daza, Rene Amaya, Guisselle Garcia-Llinas and Stefan Voß*

Thursday, September 22, 9:00-10:30; Session: Sustainability II

Locating Hydrogen Production in Norway Under Uncertainty

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Abstract. In this paper, we study a two-stage stochastic multi-period facility location and capacity expansion problem. The problem is motivated by the real-world problem of locating facilities for green hydrogen in Norway. We formulate a model with modular capacities. Investment into a facility and expansion costs represent long-term costs. For each capacity, we define a convex short-term production cost function which enables to capture economies of scale in investment as well as in production. The objective is to minimize the total expected investment, expansion, production and distribution costs while satisfying demand in each scenario. We solve the problem using the sample average approximation. The results from solving the problem show that the stochastic problem leads to a lower installed capacity in the opening decisions than the expected value problem.

Keywords: Stochastic Facility Location, Capacity Expansion, Hydrogen Supply Chain

Thursday, September 22, 9:00-10:30; Session: Sustainability II

How can a Refrigerated Warehouse be used to store Energy?

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Abstract. Refrigerated warehouses are essential for a well-functioning cooling supply chain. Here, the ambient temperature is regulated around the clock, while the refrigeration system is turned on in recurring time intervals. The idea of this paper is to use the refrigerated warehouse as a virtual battery. The temperature inside the warehouse is cooled down when the market price is low. Thus, the energy is stored and the use of the refrigeration system during times of high electrical prices is avoided. This concept can be seen as a part of the demand-side management, where monetary incentives are provided to electricity consumers to adapt their load profile in a grid supporting manner. The use case is based on the electricity price of the day-ahead-market. The characteristics of this electricity market require an electricity price prediction. This is based on the availability of renewable energy sources and the predicted electricity demand. The implementation is done via a time-driven discrete simulation model of a real refrigerated warehouse operating in the normal cooling range (above 0 °C). The simulation model's first control option is the use of deterministic strategies which result in a decrease of the electricity cost of up to 7 %. The second more complex control option via the so-called solution finding exploits electricity cost savings of 37%. To receive satisfactory results, a highly detailed implementation in the warehouse and well predicted electricity price have proven to be necessary. Therefore, this study can be seen as a first step on the way to use refrigerated warehouses as virtual batteries.

Thursday, September 22, 9:00-10:30; Session: Sustainability II

Keywords: Demand-Side Management, Load Management, Discrete Simulation, Refrigerated Warehouse, Energy Efficiency, Virtual Battery, Energy Storage

Thursday, September 22, 9:00-10:30; Session: Sustainability II

A Practical Solution Approach for the Large-Scale Multi-Depot Vehicle Routing Problem

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Abstract. This research aims to gain greater understanding and to drive improvement of the current last-mile logistics planning of a leading retailer, in which a large fleet of vans delivers online orders from secondary distribution centers to customers. Using the current and new logistics plans, the research analyses the environmental impact of their deliveries and the quality of service when adjusting important input parameters. To improve the quality of transportation plans, we analyze the current algorithms, identify key issues, and then propose algorithmic alternatives to improve last-mile logistics plans. We measure the average number of customers, the number of vans, among other KPIs, using the improved last-mile logistics plans compared to those of the current; and the additional revenue each of the alternatives can generate in comparison to the current last-mile logistics plans. To measure the impact on the environment, we estimate the amount of CO2 emitted. To measure the quality of service, we calculate the percentage of customers that are served outside of their selected service time window. We examine how customer service time windows affect the last-mile logistics plan by measuring the difference between the amount of CO2, the number of customers that are served outside of their chosen time windows. The initial results show that proposed algorithms result in last-mile logistics plans that can serve more customers with fewer vehicles, and greater quality of service. Also, analyzing the impact of time windows showing that customer service time windows are a crucial factor that affects the quality of last-mile logistics planning: increasing the customer time window reduces the

number of vans reducing the impact to the environment and increases the quality of service (e.g., fewer customers served outside of their chosen time windows). This research results in last-mile logistics plans with more customers and fewer vans, which can translate into additional revenue, cost savings and reductions in CO2 emissions. Furthermore, larger time windows contribute to a green routing perspective in the sense of the amount of CO2 emissions being minimized.

Keywords: Vehicle Routing Problem, Green Logistics, Last-Mile Logistics Planning, Service Levels

Thursday, September 22, 9:00-10:30; Session: Sustainability II

Hinterland Intermodal Transport Routing as an Added Value Tool for Port Community Systems: a Colombian Case Study

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Abstract. In the context of port communities, one of the most commonly used technological developments are Port Community Systems (PCS). The typical service offer of a PCS includes information exchange, electronic exchange of customs declarations and responses, control, tracking and tracing of the goods, and statistics. However, it has been argued that it is necessary to evolve the existing PCS into a renewed version, more suitable to the novel requirements posed by both developed and emerging economies, incorporating as well the surge of new technologies. Such a renovation should care for integrating new value-added services to the aforementioned typical PCS service offer. Therefore, we propose a new hinterland intermodal routing service to be included to the regular PCS functionality. Such a new service is based on the development of a built-in optimization model, delivering a sustainable and cost-effective intermodal transport network. The proposed hinterland intermodal routing service could help mitigating the environmental impact of the Colombian hinterland transport and the national transportation costs, increasing the nation's competitiveness and sustainability through a value-added service of a PCS.

Keywords: Freight Transport, Intermodality, Port Community Systems, Intermodal Routing Service, Optimization Model

Supply Chain II

Thursday, September 22, 9:00-10:30

Chair: Anna-Maria Nitsche

1 **Freight Costs Versus Service Level: Optimizing the Distribution of a Materials Trader.** *Thomas Bömer and Anne Meyer*

2 **Redesigning Agricultural Supply Chains to fully valorise Perishable Crops.*** *Marloes Remijnse, Sonja Rohmer and Ahmadreza Marandi*

3 **Reference Model for Data-Driven Supply Chain Collaboration.** *Anna-Maria Nitsche, Christian-Andreas Schumann and Bogdan Franczyk*

Thursday, September 22, 9:00-10:30; Session: Supply Chain II

Freight Costs Versus Service Level: Optimizing the Distribution of a Materials Trader

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Abstract. Constantly rising freight rates can force traders to reduce transportation costs at the expense of their service promise of next-day delivery. In this paper, we examine the potential freight costs savings for the local distribution network considering two temporal and one spatio-temporal consolidation concept: Consolidation Period, Delivery Profiles, and Area Forwarding & Milk Runs. We examine the potential savings arising from these concepts using the 2020 orders from a local distribution center of a German materials trader as a case study. We describe the problems and solution methods of these concepts both on the tactical and the operational planning levels.
For the Area Forwarding & Milk Run concept we additionally introduce an effective math-heuristic to solve the instances of the case study. For all three consolidation methods significant savings can be achieved.
A consolidation for two days saves 11.6% of the freight costs. Using delivery profiles lead to cost cuts of up to 8.9%. The transport concept selection between area forwarding and milk runs achieves a maximum reduction of freight costs of 23.8%. These findings can be used by departments within the company - such as supply chain management, transport or sales - to assess whether freight costs savings justify the lowering of the service level.

Keywords: Delivery Profiles, Milk Runs, Freight Cost

Thursday, September 22, 9:00-10:30; Session: Supply Chain II

Redesigning Agricultural Supply Chains to Fully Valorise Perishable Crops

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Abstract. Currently, humanity is facing an immense challenge in feeding the growing world population while a significant amount of food is wasted. Therefore, it is crucial to use the limited resources on our planet in a more efficient way. However, this remains difficult because edible and valuable food streams are not used to their full potential. For example, cauliflower leaves and carrot foliage are often left on the land (Bockstael, T., De Mey, V., & Miserez, A., Bioboost-Interreg, 2019). Yet, these streams could be used for processed products such as soups or sauces. Valorising these streams could, hence, improve food security and result in more efficient land use, especially in low-income countries (FAO, 2019, "The state of food and agriculture: Moving forward on food loss and waste reduction."). The question is: how can we profitably and sustainably valorise these streams?

To address this issue, this research focuses on strategic decision-making related to the use of resources at the harvesting stage and the processing units of food supply chains. Hence, this research looks at ways to redesign the supply chains such that crops are valorised for food purposes to the greatest extent possible. For this, we develop a mathematical programming model that defines the product portfolio by selecting from a set of recipes that can be made from the ingredients. The considered options include the wholesale of raw materials but also highly processed products that often have longer shelf lives. An important factor determining the possible production options and the shelf life of products is quality decay. Thus, the model tracks the quality decay in the supply chain to better decide which products can be processed and sold at which stage. We use two performance indicators to find the best product portfolio and corresponding supply chain configuration: profit maximisation and environmental impact minimisation. By

analysing the Pareto frontier, we investigate the trade-offs between different objectives. Additionally, we show the effect that valorisation has on the quality of products and give insights into the optimal processing setup.

Keywords: Food Supply Chain, Mathematical Programming, Product Portfolio, Sustainability, Quality

Thursday, September 22, 9:00-10:30; Session: Supply Chain II

Reference Model for Data-Driven Supply Chain Collaboration

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Abstract. This paper presents a reference model for data-driven supply chain collaboration (SCC) designed based on the principles of design science research and the process model for empirically grounded reference modelling. Increasingly competitive and global supply networks require a wider application of collaborative supply chain management. Thus, the different aspects of SCC, including inter-organizational exchange of data and knowledge as well as the integration of novel technologies, such as artificial intelligence, are essential factors for organizational growth. This paper attempts to fill the gap of a missing overview of this field by providing the results of the development of a comprehensive framework of data-driven SCC. Due to the interdisciplinary focus and approach combining information systems, design science and management research, the paper contributes to the academic debate by providing a macro-level perspective on the topic of SCC and a conceptualization and categorization of data-driven SCC. Furthermore, this paper presents a valuable contribution to practice and supply chain processes in organizations across sectors by delivering a practical contribution in the form of an adaptable reference framework for application in the information technology sector.

Keywords: Empirically Grounded Reference Modelling, Supply Chain Collaboration, Artificial Intelligence, Information Systems, Design Science Research

Thursday, September 22, 11:00-12:00; Plenary Session II

PLENARY SESSION II

Chair: Jessica Rodríguez-Pereira

Agents Collaboration for Discrete Location

Elena Fernández

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Abstract. We address a new class of discrete location problems that study the potential collaboration of agents that operate on a common network within a given time horizon. We assume that several agents offer their services to an existing set of users, whose demand for each agent is known at each time period. We consider prize-collecting models in which served demand produces a profit and it is possible to reject some existing service calls. Agents may collaborate in several aspects. A plant located at a site that, in principle, corresponds to one agent is opened and operated by a different agent (who may have different costs). Also service calls for an agent can be served from a facility operated by a different agent. Such a model includes as particular cases several well-known location problems. We show theoretically that the considered model may lead to arbitrarily large improvements relative to the non-collaborative setting. We also present mixed-integer linear programming formulations for them, as well as an algorithmic solution scheme. The results of extensive computational experiments are presented and analyzed.

Maritime Logistics III

Thursday, September 22, 12:00-13:30

Chair: Frank Meisel

1 **Impact of Rubber-Tired Gantry Crane Dimension on Container Terminal Productivity.** *Marvin Kastner and Carlos Jahn*

2 **A MILP Model to optimize the Containers' Transfer for their Train Loading.*** *Daniela Ambrosino, Silvia Siri and Haoqi Xie*

3 **Optimization of a Ship-based Logistics System for Carbon Capture and Storage.** *Anders Bennæs, Martin Skogset, Tormod Svorkdal, Kjetil Fagerholt, Lisa Herlika, Frank Meisel and Wilfried Rickels*

4 **Rethinking Cyclic Structures in Liner Shipping Networks.*** *Daniel Wetzel and Kevin Tierney*

Thursday, September 22, 12:00-13:30; Session: Maritime Logistics III

Impact of Rubber-Tired Gantry Crane Dimension on Container Terminal Productivity

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Abstract. When a Container Terminal (CT) is being newly planned or re-designed, the yard equipment must be selected before the yard layout can be planned. Commonly, Rubber-Tired Gantry cranes (RTGs) are selected for stacking the laden containers in the yard. These are available in different dimensions, typically designed to span over yard blocks between five to nine containers wide. The lift heights usually support four, five, or six containers that are stacked on top of each other. But what are the implications of the selected RTG dimension on the yard productivity? In a step-by-step analysis, the stacking density and yard productivity are estimated for the different RTG dimensions. The yard area of the CT MSC Valencia serves as an example and reference. It is shown that the stacking density ranges from 233 to 320 Twenty-foot Ground Slots (TGS) per hectare (ha) and from 853 to 1744 Twenty-foot Equivalent
Units (TEU) per ha. When the simplistic rule of one RTG per yard block is applied, with increasing RTG spans the yard productivity decreases from 360 to 240 moves per hour. An analysis of operational data indicates that the crane cycle times differ slightly but are less relevant in daily operations. It is concluded that RTG deployment strategies (avoiding idling times) should be further investigated considering a range of commonly purchased RTG dimensions. Furthermore, the impact of higher container stacks on the number of reshuffles needs to be revisited in this context.

Keywords: Container Yard Layout, Equipment Selection, Maritime Logistics

Thursday, September 22, 12:00-13:30; Session: Maritime Logistics III

A MILP Model to optimize the Containers' Transfer for their Train Loading

Daniela Ambrosino, Silvia Siri, Haoqi Xie

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Abstract. In this work, we deal with a problem arising in the maritime container terminals that is the operations' sequencing that must be performed by a given number of reach stackers for moving containers from their rail yard locations to their assigned train slots.

As stressed in [1] the container terminal is an intermodal node with highly interrelated operating systems, having a crucial role in transferring containers from vessels to inland transportation modes. The problem under investigation is inspired from a real case of an Italian port.

In the analyzed port, inbound containers are stacked in a storage park near the rail tracks after their unloading from vessels and generally it is not known when and on which train they will leave the terminal. Thus, in the rail yard, containers waiting to be loaded on different trains are put together, and it is inevitable to have to reshuffle some containers when transferring them to the train for their loading.

When a list of containers to load on a train is known, together with their exact position on the wagons, (thanks to a previous load planning phase, see [2] for some details on the load train planning problem) some unproductive movements might occur: a reach stacker might have to reshuffle some containers, or wait / move without any container. These situations will harm the efficiency and must be minimized during the loading process.

We assume that the storage park is adjacent to the wagons, that permits us not to include the distance among yard slots and wagon slots in our analysis.

To optimize the containers' transfer for their train loading, a MILP model is proposed together with some valid inequalities. Moreover, a heuristic algorithm based on a decomposition approach is then presented for solving real-scale instances. The decomposition is obtained by splitting the loading list, i.e., the set of containers to load on the train in sub-sets. The cardinality of the sub-sets influences the quality of the obtained solution, in terms of both unproductive movements and required CPU time.
To test the effectiveness of the approaches, two different campaigns based on real-scale instances of different size have been performed. In each campaign, several numerical experiments have been conducted to evaluate the performance of different valid inequalities and to define the cardinality of the sub-sets for the heuristic approach.
Moreover, a scenarios analysis has been conducted; the performance of solution approaches with two different storage situations has been investigated.
The solution approaches and the obtained results are going to be presented during the conference.

Keywords: Operation Sequencing, Maritime Container Terminal, Train Loading Plan, Mixed-Integer Programming, Valid Inequalities, Heuristic Algorithm

References:

Carlo, H. J., Vis, I. F., & Roodbergen, K. J. (2014). Storage yard operations in container terminals: Literature overview, trends, and research directions. EJOR, 235(2), 412-430.

Ambrosino, D., & Siri, S. (2015). Comparison of solution approaches for the train load planning problem in seaport terminals. Transp. Res. Part E, 79, 65-82.

Thursday, September 22, 12:00-13:30; Session: Maritime Logistics III

Optimization of a Ship-based Logistics System for Carbon Capture and Storage

Anders Bennæs[1], Martin Skogset[1], Tormod Svorkdal[1], Kjetil Fagerholt[1], Lisa Herlika[2], Frank Meisel[2], Wilfried Rickels[3]

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Abstract. Carbon Capture and Storage (CCS) is the process of capturing CO2 before it enters the atmosphere, transporting it, and then storing the CO2 in a permanent underground storage site. CCS can play an important role to reach the two-degree goal set by the Paris Agreement, and with this in mind, we study the so-called Ship-Based CCS Logistics Problem (SCLP). The SCLP deals with designing a cost-effective ship-based logistics system to ensure that CO2 captured from emission sources in the hinterland of loading ports is transported to unloading ports nearby the final storage sites. As part of this, one needs to determine the intermediate storage capacities at the loading ports, ship fleet size and mix, fleet deployment and sailing speeds along each chosen route. To solve the SCLP, we propose a new mixed-integer programming model, where candidate ship routes are generated as input. We use our optimization model to analyze three future supply scenarios based on estimations of the volume of captured CO2 from emission sources in mainland Europe that is brought via ports of Antwerp, Dunkirk, Rotterdam and Wilhelmshaven to Norwegian storage sites. Our computational results show that the logistics cost per tonne of CO2 will be around 10 euros in low-volume scenarios and drop to about 8 euros in high-demand scenarios due to economies of scale. In the considered high-demand scenario for the year 2050 about 100 ships are required to perform several thousand round trips per year within the considered port network.

Thursday, September 22, 12:00-13:30; Session: Maritime Logistics III

Keywords: Carbon Capture and Storage, Maritime Logistics System, Optimization, Case Study

Thursday, September 22, 12:00-13:30; Session: Maritime Logistics III

Rethinking Cyclic Structures in Liner Shipping Networks

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Abstract. Liner shipping networks are a central feature of modern supply chains that consist of cyclical, periodic services operated by container ships. This specialized, cyclical structure eases planning for both shipper and carrier, but the combination of cyclical planning with the available time windows at ports can lead to inefficient sailings. We propose to relax the cyclical assumption and allow ships to move between services to avoid inefficient connections without interrupting container flows. From the view of a shipper, the cyclical and periodic properties of the services still hold, and the liner carrier can offer a more efficient overall network. The resulting optimization problem consists of a combined vessel routing problem and cargo allocation problem, resulting in large and difficult instances. We model the problem using mixed-integer linear programming and use column generation to efficiently find solutions. We show using real-world data that giving flexibility to a liner network can result in a significant cost reduction over standard cyclical schedules.

Keywords: Maritime Applications, Routing Problem, Column Generation

Last-Mile Delivery

Thursday, September 22, 12:00-13:30

Chair: Eduardo Lalla-Ruiz

1 **Two Echelon Vehicle Routing Model based on Collaboration Points in Last Mile Delivery.*** *Sagar Pingale, Arshinder Kaur and Renu Agarwal*

2 **The Dynamic Drone Scheduling Delivery Problem.** *Giovanni Campuzano, Eduardo Lalla-Ruiz and Martijn Mes*

3 **Integrating Clustering Methodologies and Routing Optimization Algorithms for Last-Mile Parcel Delivery.** *Angie Ramirez-Villamil, Jairo R. Montoya-Torres, Anicia Jaegler, Juan M. Cuevas-Torres, David L. Cortés-Murcia and William J. Guerrero*

Thursday, September 22, 12:00-13:30; Session: Last-Mile Delivery

Two-Echelon Vehicle Routing Model based on Collaboration Points in Last-Mile Delivery

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Abstract. Collaboration among different logistics service providers in last-mile delivery has emerged as an effective way to serve customers and achieve enhanced freight transportation efficiency. Last-mile logistics service providers are often encountered with the problems such as empty trips, low load factor, long dwell times, large number of deliveries to an individual customer and it is here where collaboration across stakeholders is considered an effective way to minimize operational inefficiencies. Existing studies on collaboration in two-echelon distribution systems have focused on sharing strategic assets such as logistics facilities (Distribution Centres), intermediate satellites, or logistics resources, such as driving vehicles which might not be favorable to many logistics service providers in the long run due to ownership disputes. Examining new ways, this study brings multiple last-mile logistics service providers who collaborate without sharing their strategic assets. We have formulated a Multi-Depot-Two-Echelon Vehicle Routing Problem with Collaboration Points where they exchange goods between second echelon vehicles belonging to different logistics service providers. The study assumes balanced distribution i.e., product exchange of the same quantity at the collaboration points to take care of equal profit-sharing mechanisms; thus avoiding any marketing and branding issues between different logistic service providers. This routing method using collaboration points is formulated as a multi-integer linear programming model that minimizes the total distribution cost and

is tested on randomly generated instances. The analysis is compared with the two existing distribution methods from extant literature namely 'Non-Collaborative distribution' and 'Collaboration with shared logistics facilities and resources.' When compared with these two established methods, results suggest that the proposed collaborative distribution strategy can reduce the cost up to 5% to 8% relative to non-collaborative scenarios. The future work will include the development of a balanced profit-sharing mechanism to make the model more versatile to tackle the unbalanced distribution of products at collaboration points. Whilst there are some limitations, this model will facilitate fleet managers to achieve efficient fulfillment and increased profitability in last-mile delivery.

Keywords: Last-Mile Logistics, Routing, Two-Echelon Collaboration

Thursday, September 22, 12:00-13:30; Session: Last-Mile Delivery

The Dynamic Drone Scheduling Delivery Problem

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Abstract. Logistics play an important role in today's last-mile economy. Therefore, companies constantly seek for improving their delivery system towards more efficient and sustainable management of parcel distribution. In this paper, we study the Dynamic Drone Scheduling Delivery Problem. The objective is to minimize the delayed deliveries by a fleet of drones located in a central drone station, taking into account the uncertain arrival of parcels, soft time windows, and energy requirements. We develop a Markov Decision Processes (MDP) formulation and solve it approximately by implementing a value-based Reinforcement Learning (RL) approach. We compare our approach with several heuristic dispatching policies and provide insights into the efficiency of our RL algorithm when facing different delivery scenarios.

Keywords: Drone Scheduling, Battery charging, UAV, Last Mile, Reinforcement Learning

Thursday, September 22, 12:00-13:30; Session: Last-Mile Delivery

Integrating Clustering Methodologies and Routing Optimization Algorithms for Last-Mile Parcel Delivery

Angie Ramirez-Villamil[1], Jairo R. Montoya-Torres[1], Anicia Jaegler[2], Juan M. Cuevas-Torres[1], David L. Cortés-Murcia[1], William J. Guerrero[1]

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Abstract. This paper aims to design a two-echelon parcel distribution network modeled as the Two-Echelon Vehicle Routing Problem (2E-VRP). In this problem, e-cargo bikes perform the last-mile delivery. In fact, this transportation mode is positioned as a promising alternative to make last-mile delivery. Studies show cost and carbon dioxide equivalent (CO2e) emissions savings with cargo bikes setup compared to conventional vans. To solve this problem, a three-stage decomposition algorithm is proposed. In the first stage, the non-supervised machine learning clustering method Two-dimensional (2D) k-means is considered to allocate the clients to the centroid of the cluster that will be the satellite for the distribution network. The second and third stages comprise the second and first echelon routing. The last two stages use a heuristic based on the Nearest Neighbor (NN) procedure. Two local search operators were used as improvement algorithms for the solution given by the NN in the second stage. The use of machine learning techniques can speed up algorithms specifically for this problem. Moreover, there are scarce studies that use the 2D-k-means algorithm in this urban distribution network context. Experiments are run using a small instance based on real data from a delivery company in the city of Paris, France. Results show that the fixed costs and the cost of energy consumption of the e-cargo bikes are cheaper than the van considered in the first echelon. Also, a reduction of 8.2% in terms of travel time is obtained when the Relocate local search is

applied. Additional savings are achieved in performance indicators.

Keywords: Sustainability, Urban Logistics, Last-Mile Delivery, Routing Problems, Smart City

Social Good

Thursday, September 22, 12:00-13:30

Chair: Maria Isabel Gomes

1 **The Heterogeneous Dial-a-Ride Problem with Trip Time Prediction**. **Laura Portell and Helena Ramalhinho*

2 **Optimizing the Logistics of Food Distribution by Social Food Pantries considering Technical and Social Criteria**.**Marc Juanpera, Laia Ferrer-Martí, Bruno Rodés, Pol Gil-Figuerola, Albert Soler-Noguera, Rafael Pastor*

3 **Applying Analytics in Social Care Logistics for Elderly Population: a Case Study in Rio de Janeiro**. * *Luciana Pessoa, Raphael Bittencourt, Paula Maçaira, Helena Ramalhinho and Jésica de Armas*

4 **Social Logistics: an Operations Research Perspective.*** *Maria Isabel Gomes*

Thursday, September 22, 12:00-13:30; Session: Social Good

The Heterogeneous Dial-a-Ride Problem with Trip Time Prediction

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Abstract. Defining routes for door-to-door services for people with reduced mobility is essential. Dial-a-ride problems (DARP) consist of designing routes for transporting people from a specific origin to a specific destination.
In this work, we propose a mathematical model for solving a special case of the DARP considering heterogeneous vehicles, such as adapted taxis and buses with different capacities, and heterogeneous users with reduced mobility. Furthermore, we are taking into account other specific needs such as a maximum travel time for the users, time windows, and a support person when required.
We also propose a predictive model for calculating the duration of the trips. This model estimates the vehicle trip duration between two points, considering the day and weekday hours and is used as input data for solving the DARP.
The results use data from the Special Transportation Service for People with Reduced Mobility in the city of Barcelona.

Keywords: Dial-a-Ride Problem, Vehicle Routing Problem, Predictive Model, Mathematical Model, Persons with Reduced Mobility

Thursday, September 22, 12:00-13:30; Session: Social Good

Optimizing the Logistics of Food Distribution by Social Food Pantries considering Technical and Social Criteria

Marc Juanpera[1], Laia Ferrer-Martí[1], Rafael Pastor[1], Bruno Rodés[1], Pol Gil-Figuerola[1], Albert Soler-Noguera[2]

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Abstract. Before the COVID-19 pandemic, around a 3% of the European population suffered from food insecurity. This number is likely to have recently increased due to the global instability, also as a result of the Ukrainian war, which has caused food shortages in supermarkets and significant price rises. To mitigate this need, Europe has an established network of non-profit entities like food "banks" and "pantries" that periodically distribute food to the most vulnerable population. Food pantries, such as El Rebost (Terrassa, Spain), receive scheduled arrivals of food products from the EU and larger food banks, and distribute them to beneficiaries through pre-defined appointments of a monthly basket collection. However, it is often complex to ensure that the food baskets are balanced in terms of the nutritional needs of each person. In addition to the scheduled arrivals, these pantries occasionally receive significant quantities of an unexpected product about to perish, that sometimes may be very specific (e.g., gluten-free, vegan). Such unexpected arrivals are also distributed through the common basket distribution, which might result in inequalities, since large quantities of products can be delivered to non-ideal beneficiaries according to the product characteristics.

In this context, the work being developed in close collaboration with El Rebost has two objectives:

1. To develop a quick and targeted procedure for the urgent distribution of food products about to expire.

2. To optimize the composition of the food baskets delivered monthly to increase the balance of the nutritional support given to all beneficiaries.

Regarding the first objective, the procedure developed assists with the selection of the most appropriate beneficiaries to deliver a product, according to the families' and products' characteristics (gluten-free, vegan, etc.). The procedure also employs free and common-use tools to notify the distribution and allow the beneficiaries to book an appointment of collection, in order to bridge the gap to a population not usually used to technological tools. In this regard, formative material has been created to explain how to manage a delivery by El Rebost staff, majorly elderly volunteers, and how to book an appointment by the beneficiaries. In 2021, 7 deliveries have successfully distributed 129 lots of product to the ideal beneficiaries.

Regarding the second objective, a MILP model has been developed to establish the composition of the food baskets in order to maximize the fulfilment of the nutritional needs for all the families while maintaining the variety of products El Rebost provides. 5 age groups (with different nutritional needs), 10 nutrients and

2 food constraints (gluten free and lactose intolerance) have been considered. Currently, test examples with 100 families based on real data of El Rebost have been solved and the nutritional fulfilment has been overcome by a minimum of a 16% El Rebost solution.

Keywords: Food Pantry, Food Baskets, Distribution Optimization, Mathematical Programming, Decision Making

Thursday, September 22, 12:00-13:30; Session: Social Good

Applying Analytics in Social Care Logistics for Elderly Population: a Case Study in Rio de Janeiro

Luciana Pessoa[1], Raphael Bittencourt[1], Paula Maçaira[1], Helena Ramalhinho[2], Jésica de Armas[2]

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Abstract. The elderly population is growing all over the world, and this population is requiring more care services. This work aims to assess the distribution of the demand for elderly care services in the neighborhoods of Rio de Janeiro city. This analysis will help decision-makers and policymakers identify priority areas for investments, plan locations for elderly care facilities, and improve this population's social care logistics and quality of life.
We apply descriptive analytics, such as choropleth maps, cluster analysis, and main component analysis to conduct a case study using official public databases, to identify the needs of the different areas and neighborhoods in Rio de Janeiro. The study concentrated on the following variables segmented by neighborhoods: Total Population (TP), Elderly Population (EP), Elderly Disabled Population with low-income (EDP), and Social Development Index (SDI).
The analysis identified that Rio de Janeiro has a population of 6.7 million people, among which about 10% are above 60 years old. The whole population is spread over 160 neighborhoods on 1200 square kilometers. Choropleth maps illustrated the dispersion of the variable values ranges over the neighborhoods. Such maps bring insights into the most socially underdeveloped areas and the significant concentration of senior citizens, particularly those disabled and belonging to the lower classes. Using variables SDI, EP, and EDP, Clusters Analysis segment the neighborhoods into five groups, while the Principal Component Analysis evidence the impact of each variable in the segmentation. Two of the five

clusters are antagonistic: the ones called “Wealthy and healthy” and the “Vulnerable”. The former joins the neighborhoods with the highest SDI, the average concentration of elderly, and the lowest percentage rate of low-income disabled elderly. The latter represents the highest percentage of low-income disabled elderly citizens living in areas with low-level development rates. The third cluster stands out for its high concentration of older adults. However, this group does not include a significant rate of EDP. Indeed, it is essentially composed of high SDI neighborhoods. Finally, the fourth and fifth clusters comprise areas of median SDI. However, these groups differ by the greater or lesser concentration of elderly and EDP population.
By clustering neighborhoods with similar social, economic, and infrastructure aspects, this study brings insights into potential investment areas for both public and private sectors. The following study intends to apply prescriptive analytics tools to propose optimized locations for elderly care facilities based on the findings of this work.

Keywords: Descriptive Analytics, Elderly Population, Social Care Logistics

Thursday, September 22, 12:00-13:30; Session: Social Good

Social Logistics: an Operations Research Perspective

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Abstract. ONU's Sustainable Development Goals (SDGs) address global challenges faced by all countries. Though many believe these goals are mostly directed to developing countries, the SDGs set ambitious targets for all countries. To differing degrees, social challenges such as poverty and equality are still present in developed countries (Osborn et al. (2015). "Universal sustainable development goals.", Report of a Study by Stakeholder Forum). The COVID-19 pandemic has made it even more challenging to achieve the SDGs goals concerning social issues, e.g. food insecurity, poverty and inequality. Service provision within this social context is challenging as it deals with people in a socially fragile situation. Hence, Operations Research (OR) models addressing logistics efficiency need to be thoroughly thought so they can support decision making in what we call Social Logistics. In a nutshell, Social Logistics are all logistics activities supporting service provision to people in need of social support to their day-to-day living.

In this talk, we will address two of the Social Logistics challenges faced by developed countries. We will look into them through the OR lenses having its methods as tools to support the change: home care support and the integration of people with disabilities in the workforce.

"We need to re-think our cities. Over 900 million older persons will be living in cities across the world by 2050, but our cities are not fit for this global demographic revolution." (Rosa Kornfeld-Matte). The ability to live in one's own home and community, safely and independently, as one ages is known as "Aging in place" (Morley (2012). JAMDA, 13(6), 489-92). Aging gradually brings loss of autonomy which defies the capability to keep living

at home. Health and social care support can be provided by specialized personnel and/or unspecialized caregivers making aging in place a reality. In this talk, we will show some tailoring needing to be made so that traditional routing and scheduling models can be of use to address the caregivers' routes design to provide support at patients' homes.
In the EU, over 100 million people live with least a disability. The employment to population ratio (EPR) for persons with disabilities aged +15 is about 20 pp lower than the EPR for persons without disability (UN (2018) "Disability and Development Report", New York). Recently, the Corporate Sustainability Reporting (CSR) Directive will amend the current CSR report requirements so as to incorporate "employment and inclusion of people with disabilities". Thus, companies will benefit if employing workers with disabilities. The Line Worker Assignment and Balancing problem has been studied to account for heterogenous workers (workers, w/ or w/o disabilities, execution tasks at different speeds). In this talk we will highlight some contributions that have been made on this subject.

Keywords: Logistics of Health and Social Care, Social Logistics, People with Disabilities

Thursday, September 22, 15:00-16:00; Session: Plenary Session III

PLENARY SESSION III

Chair: Helena Ramalhinho

Desigual: Logistics technologies: a journey to the flexible and scalable operations

Jorge Soriano

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Abstract. E-commerce evolution in the latest years has changed the role of the distribution centers. Operations have increased complexity due to a higher variety of products, a reduction of lead times and a high variability in demand. Companies with logistics activities; therefore, are basing their investments on automation in solutions which allow agile scalability and flexibility. Autonomous Mobile Robots (AMR) technologies are significantly helping to achieve the operational flexibility, performance, quality and cost efficiency requested. But before AMRs, several technologies were (and are) in the market in order to manage logistics operations.

Discussion will be around technology evolution in the last years, considering two main goals: scalability and flexibility.

Machine Learning

Thursday, September 22,16:15-17:45

Chair: Christopher Reining

1 **Dynamic Time Slot Pricing using Delivery Costs Approximations**. *Fabian Akkerman, Martijn Mes and Eduardo Lalla-Ruiz*

2 **Multivariate Statistical Modeling for Time-Dependent and Situation-Dependent Parameters in Stochastic Systems.** *L. Douglas Smith, Canser Bilir, Steven Stout and Michael Wieck*

3 **Deep Reinforcement Learning for Master Bay Planning on Container Vessels**.* *Jaike van Twiller and Rune Møller Jensen*

Thursday, September 22, 16:15-17:45; Session: Machine Learning

Dynamic Time Slot Pricing using Delivery Costs Approximations

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Abstract. Attended home delivery (AHD) is a popular type of home delivery for which companies typically offer delivery time slots. The costs for offering time slots are often double compared to standard home delivery services [25]. To influence customers to choose a time slot that results in less travel costs, companies often give incentives (discounts) or penalties (delivery charges) depending on the costs of a time slot. The main focus of this paper is on determining the costs of a time slot and adjusting time slot pricing accordingly, i.e., dynamic pricing. We compare two time slot cost approximation methods, a cheapest insertion formula and a method employing random forests with a limited set of features. Our results show that time slot incentives have added value for practice. In a hypothetical situation where customers are infinitely sensitive to incentives, we can plan 6% more customers and decrease the per-customer travel costs by 11%. Furthermore, we show that our model works especially well when customer locations are heavily clustered or when the area of operation is sparsely populated. For a realistic case of a European e-grocery retailer, we show that we can save approximately 6% in per-customer travel costs, and plan approximately 1% more customers when using our time slot incentive policy.

Keywords: Time Slot Management, Dynamic Pricing, Vehicle Routing, Machine Learning, Cost Approximation

Thursday, September 22, 16:15-17:45; Session: Machine Learning

Multivariate Statistical Modeling for Time-Dependent and Situation-Dependent Parameters in Stochastic Systems

L. Douglas Smith[1], Canser Bilir[2], Steven Stout[1], Michael Wieck[3]

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Abstract. Modeling stochastic behavior of operational systems requires granularity that depends on the homogeneity of entities served, resources providing service, and variability in operational conditions. To incorporate essential aspects of system performance, discrete-event simulation models can be constructed with time-dependent and situation-dependent parameters that induce appropriate systematic and random variance in characteristics of entities, resources, operating conditions, and processes. Systems with scheduled activity need to be modeled differently from systems with endogenous generators of activity. Extensive effort is required to validate the simulation models. Experiments need to be designed carefully when analyzing the effects of changes in system attributes and operating practices. Results need to be reported along various dimensions.

In this presentation, we illustrate the use of hierarchical multivariate statistical models constructed from "big data" to create time-dependent and situation-dependent parameters for discrete-event simulation models in two very different problem settings. The first setting is Charlotte Douglas Airport, a major U.S. hub for the world's largest airline, where simulation experiments focused on examining the effects of different gate-hold strategies upon flight delays and fuel burned by planes on the ground with accompanying air pollution. Data were derived from a flight tracking service that provides details of flight plans and aircraft movements in the air and on the ground.

The second setting is a generic medical practice that is adapting to changes in insurance coverage and reimbursement mechanisms

for medical services rendered under the U.S. Medicare program. Here the concern is configuring a medical practice with an appropriate mix of physical facilities, personnel, scheduling practices for its pool of patients, and terms of reimbursement for services. Data in this case were derived from all recorded patient encounters in five treatment settings (hospital inpatient, hospital outpatient, primary-care medical practices, home healthcare, and skilled nursing facilities) for a sample of one million individuals. Considered are diagnoses and services received over an entire year for each patient, medical services near the patient's place of residence, and demographic characteristics.
In the first instance, the simulation model focuses on physical activity with two-dimensional geo-spatial representation. In the second instance, the simulation model focuses on resource utilization, service levels and financial performance. We describe the choice of units of analysis for the supporting statistical models in each case, the data integration required, types of models employed (regression, logistic regression, and Poisson regression), tools constructed for building the statistical models and embedding them into the simulation models, and insights derived from their application.

Keywords: Simulation Modeling, Stochastic Systems, Airport Flight Operations, Healthcare Service Systems, Multivariate Statistical Models

Thursday, September 22, 16:15-17:45; Session: Machine Learning

Deep Reinforcement Learning for Master Bay Planning on Container Vessels

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Abstract. Container vessel stowage planning concerns itself with placing containers on port load lists onto vessels. A stowage plan can be decomposed in master bay planning to assign cargo to general areas and slot planning to place cargo into slots of bays [1]. The goal is to maximize vessel utilization on the fronthaul and minimize operational costs by creating robust stowage plans [1]. Due to stowage and seaworthiness rules, this optimization problem belongs to the class of NP-hard problems [1]. The first phase of another hierarchically decomposed NP-hard problem has recently been solved through deep reinforcement learning (DRL), which performs well on large and complex unseen instances [2]. To our knowledge, there is one piece of work on DRL for stowage optimization, which solves an incomplete slot planning problem with a single port of discharge and uniform containers [3]. Hence, novel DRL formulations are necessary to efficiently solve realistic and unseen instances.

This paper will experiment with DRL by formulating the master bay planning problem (MBP) as a finite Markov decision process, which is defined in terms of states, i.e. load lists, bay traits and capacities, and remaining cargo onboard, actions, i.e. allocating containers to bays, and rewards, i.e. total stowage cost, capacity utilization on fronthaul, and satisfying seaworthiness and stowage rules. As container allocation has no direct reward, a neural net is used to prescribe appropriate actions. Iteratively, the agent searches for an optimal policy that maximizes rewards through Markovian decision-making, whereafter network parameters are updated by proximal policy optimization. This stochastic on-policy method limits the risk of disrupting changes to solutions.

Furthermore, a simulation environment will enable learning from unobserved problem instances.
If DRL scales well for MBP, this opens a new venue for stowage research. We recognize sufficient data on vessel types, stacking rules in slot planning, and revenue management in stowage plans as future challenges. However, we believe that more AI research advances the field toward fully automated stowage planning.

Keywords: Container Stowage, Master Bay Planning, Deep Reinforcement Learning, Markov Decision Process, Maritime Logistics

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Storage Management

Thursday, September 22, 16:15-17:45

Chair: Martin Olsen

1 **SLAPStack: A Simulation Framework and a Large-Scale Benchmark Use-Case for Autonomous Block Stacking Warehouses.** *Jakob Pfrommer, Alexandru Rinciog, Sohaib Zahid, Michael Morrissey and Anne Meyer*

2 **CrossLog: Automatic Mixed-Palletizing for Cross-Docking Logistics Centers**. *Pedro Rocha, António Ramos and Elsa Silva*

3 **Oblivious Stacking and MAX k-CUT for Circle Graphs.** *Martin Olsen*

Thursday, September 22, 16:15-17:45; Session: Storage Management

SLAPStack: A Simulation Framework and a Large-Scale Benchmark Use-Case for Autonomous Block Stacking Warehouses

Jakob Pfrommer, Alexandru Rinciog, Sohaib Zahid, Michael Morrissey, Anne Meyer

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Abstract. Block stacking warehouses (BSWs), wherein products are kept in storage on the ground and/or stacked on top of each other, are ubiquitous along the supply chain. With the advent of autonomous forklifts, unmanned BSWs are an impending reality. However, to bridge the gap from isolated vehicles to a fully functioning warehouse, a vehicle control system capable of dealing with the complex interlaced problems associated with BSWs is required.
To prove the feasibility of such a control system, we contribute three key elements. Firstly, we introduce SLAPStack, an event discrete simulation framework for BSWs covering all the required decision problems.
Secondly, we present WEPAStacks, a large-scale, real-world BSW use-case containing data that spans three months of operations.
Finally, we use the SLAPStack in conjunction with WEPAStacks to test different storage location assignment problem (SLAP) strategies while using fixed unit-load selection and dispatching strategies.

Keywords: Autonomous Block Stacking Warehouses, Event Discrete Simulation, Benchmark Dataset, Storage Location Assignment Problem

Thursday, September 22, 16:15-17:45; Session: Storage Management

CrossLog: Automatic Mixed-Palletizing for Cross-Docking Logistics Centers

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Abstract. The CrossLog project aims to investigate, study, develop and implement an automated and collaborative cross-docking system (aligned with Industry 4.0) capable of moving and managing the flow of products within the warehouse in the fastest and safest way. In CrossLog, the ability to generate intelligent three-dimensional packing patterns is essential to ensure the flexibility and productivity of the cross-docking system while ensuring the stability of the palletized load. In this work, a heuristic solution approach is proposed to generate efficient pallet packing patterns that simultaneously minimize the total number of pallets required and address the weight and volume balance between pallets. Computational experiments with data from a real company demonstrate the quality of the proposed solution approach.

Keywords: Mixed Pallet Loading, Heuristics, Volume and Weight Balance

Thursday, September 22, 16:15-17:45; Session: Storage Management

Oblivious Stacking and MAX k-CUT for Circle Graphs

Martin Olsen

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Abstract. Stacking is an important process within logistics. Some notable examples of items to be stacked are steel bars or steel plates in a steel yard or containers in a container terminal or on a ship. We say that two items are conflicting if their storage time intervals overlap in which case one of the items needs to be rehandled if the items are stored at the same LIFO storage location. We consider the problem of stacking items using k LIFO locations with a minimum number of conflicts between items sharing a location. We present an extremely simple online stacking algorithm that is oblivious to the storage time intervals and storage locations of all other items when it picks a storage location for an item. The risk of assigning the same storage location to two conflicting items is proved to be of the order $1/k^2$ under mild assumptions on the distribution of the storage time intervals for the items. Intuitively, it seems natural to pick a storage location uniformly at random in the oblivious setting implying a risk of $1/k$ so the risk for our algorithm is surprisingly low. Our results can also be expressed within the context of the MAX k-CUT problem for circle graphs. The results indicate that circle graphs on average have relatively big k-cuts compared to the total number of edges.

Keywords: Oblivious Algorithms, MAX k-CUT, Stacking, Circle Graphs

Research Challenges in Logistics Organizations

Thursday, September 22, 16:15-17:45

Chair: Helena Ramalhinho

1 **Optimizing Home-Hospitalization Door-to-Door Visits at HSJD: When Technology really helps Daily Operations*.** *Xavier Ruiz*

2 **Optimizing the Line-Haul Network of an e-Commerce Delivery Company in Rapid Expansion using Operations Research*.** *Bruno Vieira*

3 **Operations Research in Hoop Carpool Company*.** *Marlyn Cuadrado*

4 **Logistics Solutions and Open Questions*.** *Ismael Rodríguez and Marco Gasparrini*

Thursday, September 22, 16:15-17:45; Session: Research Challenges in Logistics Organizations

Optimizing Home-Hospitalization Door-to-Door Visits at HSJD: When Technology really helps Daily Operations

Xavier Ruiz

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Abstract. The talk will discuss a real experience of implementing in real operations a route optimizer of a home-hospitalization door-to-door unit. The journey of implementing technology is as important as the final result and the talk will discuss, from resources needed, previous opinions and experience implementing for non-technical users.

Keywords: Home-Hospitalization, Door-to-Door Visits, Route Optimizer

Thursday, September 22, 16:15-17:45; Session: Research Challenges in Logistics Organizations

Optimizing the Line-Haul Network of an e-Commerce Delivery Company in Rapid Expansion using Operations Research

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Abstract. In third-party e-commerce delivery, parcels collected from retailers must be sorted at a (central) warehouse and then brought to the last-mile destination cities in the most cost-efficient way subject to tight timeliness and capacity constraints. This talk will show how Operations Research methods have been applied to generate feasible and high-quality solutions that support the rapid expansion of a sustainable and customer-centric parcel delivery company in Europe.

Keywords: Line-Haul Network, Rapid Expansion, Capacity Constraints, Time Restrictions

Thursday, September 22, 16:15-17:45; Session: Research Challenges in Logistics Organizations

Operations Research in Hoop Carpool Company

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Abstract. Hoop Carpool company aims to promote carpooling in cities through a mobile application. Currently, the company is improving its algorithm matching with Operations Research. In this context, a new multiobjective optimization model has been formulated to find an optimal design of routes traveled by a vehicle to serve a set of passengers, so that the number of passengers is maximized along with total cost minimization.

Keywords: Carpooling, Operations Research, Multiobjective Optimization Model

Thursday, September 22, 16:15-17:45; Session: Research Challenges in Logistics Organizations

Logistics Solutions and Open Questions

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Abstract. Hedyla Technologies is a software development company oriented to provide solutions to real-world problems in the logistics space. We are mainly focused in routes optimisation, but we are also involved in several projects that include production optimisation and palletization. In our presentation we will give a brief explanation of our main solutions, research directions and open questions.

Stochastic and Robust Optimization

Friday, September 23, 9:00-10:30

Chair: Abtin Nourmohammadzadeh

1 **A Matheuristic Approach for the Coloured Travelling Salesman Problem with Multiple Depots, Non-Deterministic Edge Weights and a Robust Objective.** *Abtin Nourmohammadzadeh and Stefan Voss*

2 **Robust Solutions for the Home Social Care Scheduling Problem under Uncertainty**.* *Daniel Badell and Jésica de Armas*

3 **Benders Decomposition for a Carsharing Pricing Problem under Uncertainty.*** *Giovanni Pantuso*

Friday, September 23, 9:00-10:30; Session: Stochastic and Robust Optimization

A Matheuristic Approach for the Coloured Travelling Salesman Problem with Multiple Depots, Non-Deterministic Edge Weights and a Robust Objective

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Abstract. The coloured travelling salesman problem (CTSP) is a special variant of the multiple TSP (MTSP), where there are a number of salesmen having each a colour and a set of cities which also have one or more colours. Each salesman is only allowed to visit the cities which have the same colour as his. Like in the MTSP, the goal of the CTSP is to cover all the cities exactly once with the tours of all salesmen while the total cost of them has to be minimised. This problem represents many real-world problems such as press print scheduling, crew scheduling, interview scheduling, hot rolling scheduling, workforce balancing etc.
In this work, a CTSP is addressed with multiple depots and non-deterministic edge weights (edge traversal costs). Five different values are considered as the possible costs of traversing an edge and the combination of these values of all edges makes the probable scenarios. This conforms with the reality since traversal costs do not only depend on the route length but change due to variable fuel costs or road traffic flows etc. A robust objective function is defined for the mathematical model of the problem which seeks to minimise the total squared deviation from the optimal objective values based on all scenarios.
As this problem has been already proved to be NP-hard, a matheuristic is devised to cope with it, especially for large sizes. The matheuristic works based on the concept of the partial optimisation metaheuristic under special intensification conditions (POPMUSIC). The main framework of this algorithm is a genetic algorithm (GA) where in each iteration other than the usual GA

operators such as selection, crossover and mutation, a proportion of the population is improved according to the POPMUSIC by solving the partial mathematical models of the problem with the GUROBI solver. In addition, another part of the population is improved using neighbourhood searches according to the simulated annealing (SA) concept. The solutions which are improved by the crossover, POPMUSIC and SA are chosen based on the roulette wheel selection method while the mutation candidates are selected completely at random.
The capabilities of our solution approach are verified by computational experiments based on a broad set of benchmark instances from the TSP library and the comparison with a state-of-the-art method from the literature which works with the variable neighbourhood search (VNS).

Keywords: Coloured Travelling Salesman Problem, Matheuristics, Robust Optimisation, Partial Optimisation Metaheuristic Under Special Intensification Conditions, Genetic Algorithms, Simulated Annealing

Friday, September 23, 9:00-10:30; Session: Stochastic and Robust Optimization

Robust Solutions for the Home Social Care Scheduling Problem under Uncertainty

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Abstract. Home social care services (HSCS) are becoming a key tool to improve the welfare of society, especially for the most vulnerable part of the population. This research work studies scheduling and staff assignment problems for the HSCS in Barcelona. Given the complexity and dimension of the real problem, we propose greedy heuristics to solve it. Additionally, HSCS implicitly include uncertainty and dynamism caused by the number of possible casualties (a user absence, a caregiver sick leave, the user does not open the door, etc.) and the obligation to deliver the services. For this reason, we simulate this kind of events and propose indicators to measure the solution's robustness. Thus, the aim of this work is to obtain robust solutions to a real-case decision problem and detect features of the deterministic solutions directly related to its weakness and strengths in the stochastic environment. To make simulations as realistic as possible, we study how planning is being done when unexpected events occur in reality, and we consider real-case data to generate new scenarios. Taking into account these aspects, we define ad-hoc metrics to evaluate how uncertainty impacts the solutions proposed by the heuristic, such as job delays and broken time windows of the services. This process introduces robustness and risk analysis criteria that prove to be useful in real-case scenarios. This analysis allows ranking and choosing the most appropriate solutions through the distributions of the proposed metrics, which will thus obtain a more controlled outcome. Furthermore, it introduces criteria to adapt parameters from the heuristic and obtain more robust solutions.
For future research, we plan to study the most suitable mechanics of rescheduling services affected by unexpected factors that could

provide an integrated solution for the scheduling problem in HSCS in Barcelona.

Keywords: Home Care Scheduling Problem, Constructive Heuristics, Uncertainty, Simulation, Robustness

Friday, September 23, 9:00-10:30; Session: Stochastic and Robust Optimization

Benders Decomposition for a Carsharing Pricing Problem under Uncertainty

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Abstract. The availability of Internet and GPS technologies has catalyzed a rapid developement of carsharing during the last decade. Modern carsharing services are commonly designed for on-demand, short-term, one-way usage. That is, users are allowed to locate and rent a car without reservation and return it as soon as, and wherever, their trip ends.
Such a configuration poses new planning challenges to carsharing operators (CSOs).
Particularly, one-way rentals create frequent imbalances in the distribution of vehicles, that is an accumulation of vehicles in low-demand zones,
and vehicle shortage in high-demand zones with levels of service dropping accordingly.
As a prime form of response to these challenges, CSOs initiate staff-based vehicle relocations between stations/zones of the city before shortages occur and the research literature covers several problem settings, different levels of granularity of decisions, as well as different mathematical approaches.
Recently, pricing decisions are being considered as an alternative way to prevent and resolve imbalances in the fleet distribution. However, the research literature is still sparse, though growing.
In this talk we present a new carsharing pricing method that extends existing methods in several ways. The method takes into account (i) the impact of alternative transport services on carsharing demand, (ii) a model of customers preferences with respect to any number of both exogenous and endogenous characteristics of the service such as,
but not limited to, travel time and waiting time and, especially, (iii) the inherent uncertainty with respect to customer preferences.

The model can be formulated as a two-stage integer stochastic program.
To solve the problem we develop an exact L-Shaped method. The method is based on a compact reformulation of the integer second-stage problem, which supports an efficient exact solution algorithm. The solution method is tested in an extensive computational study. Results illustrate that the method solved to optimality or near optimality problems of realistic size within times compatible with business practice. The method outperforms a commercial solver and scales better along different dimensions. Finally, the method is compared with, and outperforms, ad-hoc metaheuristics. Nevertheless, metaheuristics provide significant room for further improvements.

Keywords: Carsharing,.Shared Mobility, Pricing,.Stochastic Programming,.Benders Decomposition

Routing

Friday, September 23, 9:00-10:30

Chair: Juan José Salazar

1 **The Long-Haul Transportation Problem with Refueling Deviations and Time-Dependent Travel Time.** *Silvia Anna Cordieri, Francesca Fumero, Ola Jabali and Federico Malucelli*

2 **ILS-RVND Algorithm for Multi-Trip Pickup-and-Delivery Problem, with Split Loads, Profits and Multiple Time Windows.** *Wahiba Ramdane Cherif-Khettaf, Atef Jaballah and Fernando Ferri*

3 **Solving the Overnight Security Service Problem.*** *Emanuele Tresoldi, Juan-José, Salazar-González and Roberto Wolfler Calvo*

4 **The Bi-Objective Consistent Traveling Salesman Problem.** *Daniel Diaz-Rios and Juan José Salazar González*

Friday, September 23, 9:00-10:30; Session: Routing

The Long-Haul Transportation Problem with Refueling Deviations and Time-Dependent Travel Time

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Abstract. Basing on the operations of an Italian company, we model and solve a long-haul day-ahead transportation planning problem combining a number of features. Namely, we account for driver hours of service regulations, time-dependent travel times, time-dependent fuel consumption and refueling deviations. The latter stems from the fact that we consider non-homogeneous fuel prices at refueling stations. Considering a given origin and destination along with the mentioned features, we propose a mixed-integer linear programming (MILP) model that determines the minimum refueling cost route. These costs are established by modeling the time-dependent fuel consumption of the truck, accounting for possible different travel speeds due to recurrent traffic congestion. Given the challenge in solving the problem, we propose a heuristic algorithm to handle it efficiently. We test our model and algorithm on 42 realistic instances accounting for road network distances. Our results show that our heuristic produces high-quality results within competitive run times.

Keywords: Long-Haul Trucks, Truck Scheduling Problem, Time Dependency, Refueling Deviations, Hours-of-Service Regulations

Friday, September 23, 9:00-10:30; Session: Routing

ILS-RVND Algorithm for Multi-Trip Pickup-and-Delivery Problem, with Split Loads, Profits and Multiple Time Windows

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Abstract. This paper deals with a real application encountered in the construction sector, which consists in a new variant of the Pickup-and-Delivery problem, including several constraints that have never been combined in the same variant, denoted MTPDPSPMTW. This problem is defined by a set of construction sites that have a delivery demand for construction materials and also a waste removal request. Each construction site has a certain profit which is computed according to the urgency of the Pickup-and-Delivery demand. Each site can be visited several times during the day, but the delivery must be done within a set of time windows specified by each site. Heterogeneous vehicles with different availabilities located at a massification and waste treatment platform must do multiple tours to serve the requests. The objective is to minimize the total travel distance and to maximize the profit. The developed method is based on the Iterated Local Search metaheuristic which uses a Random Variable Neighborhood Descent (RVND) in the Local Search Procedure. A new move named Remove-split is introduced in the local search and in the perturbation procedure, and three classical local search operators are adapted to our problem. Different implementation schemes of the proposed method are tested on a set of data instances provided by our industrial partner.

Keywords: Vehicle Routing with Pickup-and-Delivery, Split Delivery, Metaheuristic, Iterated Local Search, Vehicle Routing Problem with Profit

Friday, September 23, 9:00-10:30; Session: Routing

Solving the Overnight Security Service Problem

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Abstract. The Overnight Security Service Problem (OSSP) consists in optimizing the routes of a fleet of guards that should check buildings (customers) in an urban area for security reasons. The guards have to take care of three different types of services which are radically different. The first one is called ticket, and is the simplest and cheapest service, as well as the most required, since one and only one passage is necessary during the night. The second one is called watch and is a more careful check, requiring the access to the building. It is repeated as many times as the customer requires, and the inspection time is recorded by a mechanical control system. The third type of service is called alarm and is disregarded in this paper, since it rarely occurs and each security company manages it in a different way. This paper addresses the design of the a-priori routes for the guards of the company to serve the tickets and the watches. To reduce the costs of the solution and to guarantee a better service to customers, the routes should be planned a-priori. From the logistic point of view, a ticket service can be managed as a watch service requiring only one and fast visit. To the best of our knowledge, the first and only model addressing the problem has been proposed in [3], where the minimum and the maximum time requirement between two consecutive visits is approximated with the use of time windows constraints. Their formulation is a simplification of the real problem since the time distance between two visits to the same building is imposed too rigidly. Our model measures the actual distance by recording the instant when each visit to a customer happens. In this way, we control and constraint by bounding the

instant when the next visit to the same customer occurs. [2] introduced and addressed a related problem with the name Multi-Color Travelling Salesman Problem (MCTSP). It can be seen as a single-guard variant of the OSSP where the bounds are on the number of intermediate visits rather than on the time duration of the intermediate route. The MCTSP is related to the Black-and-White Travelling Salesman Problem introduced in [1], where a Hamiltonian tour is feasible when the number of white visits between two consecutive black visits and the time distance are upper bounded. To the best of our knowledge the OSSP and the MCTSP have been neglected in the literature. In this paper we propose several new mixed-integer linear programming models, leading to branch-and-cut algorithms for solving the problems to optimality.

Keywords: Vehicle Routing, Exact Methods, Cutting Planes

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Friday, September 23, 9:00-10:30; Session: Routing

The Bi-Objective Consistent Traveling Salesman Problem

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Abstract. This article deals with the problem of designing a route for each day of a time period to minimize the total travel cost and the discrepancy in the service time to customers visited on different days. The literature already includes exact and heuristic approaches for the variant where the first objective is minimized and the second objective is constrained by a given threshold. The variant is known as Consistent Travelling Salesman Problem. We are not aware of any previous algorithm in the literature to tackle the biobjective problem, and this article proposes three compact formulations for it. Each formulation is suitable for approaching the problem through the well-known weighted-sum method for multiobjective optimization, where some Pareto-optimal solutions are sequentially determined by systematically changing the weights among the objective functions. We perform a computational study of results obtained by applying the formulations on adaptations of three TSPLIB instances.

Keywords: Travelling Salesman, Time Consistency, Branch-and-Cut

Urban Logistics

Friday, September 23, 9:00-10:30

Chair: Marc Juanpera

1 **Fleet Size Control in First-Mile Ride-Sharing Problem.** *Jinwen Ye, Giovanni Pantuso and David Pisinger*

2 **Industrial Waste Collection Optimization: a Real-World Case Study in Northern Italy.** *Andrea Chiussi, Gabriel de Paula Felix, Manuel Iori and André Gustavo dos Santos*

3 **Integrated Path Planning and Task Assignment model for On-Demand Last-Mile UAV-Based Delivery**. *Jose Escribano Macias, Huan Chang and Panagiotis Angeloudis*

Friday, September 23, 9:00-10:30; Session: Urban Logistics

Fleet Size Control in First-Mile Ride-Sharing Problem

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Abstract. The first-mile problem, which refers to the design of transport services that connect passengers to their nearby transit station, has attracted growing attention in recent years. In this paper we consider first-mile ride-sharing services and study the problem of optimally determining the fleet size and assigning vehicles to transport requests. We formulate the problem as a mixed-integer program and present a number of numerical experiments to analyse different configurations of the service, namely with and without fleet control (FC). The result shows that a configuration with FC is superior in terms of profits while service rates can be higher in a configuration without FC, depending on the revenue-sharing mechanism.

Keywords: Fleet Control, First-Mile Ride-Sharing

Friday, September 23, 9:00-10:30; Session: Urban Logistics

Industrial Waste Collection Optimization: a Real-World Case Study in Northern Italy

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Abstract. In this work, we present a real case application of a Roll-on-Roll-off Vehicle Routing Problem (RRVRP) that arises at a waste collection company in Northern Italy. Compared to other RRVRP applications, where large containers are emptied and moved, our problem presents two additional types of services regarding the collection of bulk waste materials. Moreover, the problem deals with customer selection based on an objective function with two components: outsourcing costs incurred when customers are given to a third-party logistic operator, and internal routing costs. We model the RRVRP as a Mixed-Integer Program and we solve it through a commercial solver and a simple but effective Iterated Greedy algorithm. Computational results are provided on 30 real case instances. Solutions provided by the Iterated Greedy algorithm are constantly better than the ones implemented by the company, showing that relevant cost reduction can be obtained with a limited computational effort.

Keywords: Roll-on-Roll-off Vehicle Routing Problem, Industrial Waste Collection, Iterated Greedy Algorithm

Friday, September 23, 9:00-10:30; Session: Urban Logistics

Integrated Path Planning and Task Assignment model for On-Demand Last-Mile UAV-Based Delivery

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Abstract. Recent technological advancements and investments have transformed Unmanned Aerial Vehicles (UAVs) into a credible and reliable tool for the provision of on-demand last-mile logistics services. Despite this, few studies have developed integrated task assignment and path planning models that consider dynamic environments and stochastic demand generation. This paper addresses this research gap by developing a Geometric Learning path planning approach, coupled with a task assignment model formulated as a mixed-integer programming model. The performance of the approach is evaluated against a dynamic programming method, and a First-In-First-Out heuristic which serves as the baseline. A case study based on the City of London is proposed to demonstrate the applicability of the integrated model. Results demonstrate the effectiveness of the mixed-integer approach in coordinating the UAV fleet compared to the other methods, with the dynamic programming providing higher returns for large fleet sizes.

Keywords: Path Planning, Task Assignment, Pickup-and-Delivery, Unmanned Aerial Vehicle

Friday, September 23, 11:00-12:00; Round Table

Humanitarian Logistics Round Table

Chair: Jessica Rodríguez-Pereira

Abstract. What are the main challenges in humanitarian logistics? How can Computational Logistics help in this field? Nothing better than knowing the details from people who work directly in humanitarian organizations. Thus, some of them provide their point of view and explain the barriers and opportunities in an interesting debate.

Public Transport

Friday, September 23, 12:00-13:30

Chair: Cebrina Lindstrøm

1 **Solving a School Bus Routing Problem in Rural Areas: An Application in Brazil.** *Letícia Caldas, Rafael Martinelli and Bruno Rosa*

2 **IT Governance in Public Transport -- An Open Agenda? *** *Liping Ge*

3 **Group Consistent Dial-A-Ride using Adaptive Large Neighborhood Search.*** *Cebrina Lindstrøm and Stefan Ropke*

Friday, September 23, 12:00-13:30; Session: Public Transport

Solving a School Bus Routing Problem in Rural Areas: An Application in Brazil

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Abstract. School transport is essential to guarantee the access and permanence of students in public schools, especially in rural regions, where students are located in large areas with low density and roads are in precarious situations. The present work aims to apply an Iterated Local Search metaheuristic to route 13,664 students in the rural areas of Rio de Janeiro state, Brazil. To reach this goal, the School Bus Routing Problem is considered with a heterogeneous fleet to minimize the total cost, considering the vehicle capacity constraints and maximum travel distance. The method is applied to the Rio de Janeiro State data to fill the gap between school practices and academic models and quantify potential economic gains. Computational experiments show that when comparing the method's results against the routes used in practice, a reduction of 40.5% in the average cost of the routes and 46.0% in the average mileage per student is obtained.

Keywords: School Bus Routing Problem, Iterated Local Search, Rural School Transport, Metaheuristic

Friday, September 23, 12:00-13:30; Session: Public Transport

IT Governance in Public Transport -- An Open Agenda?

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Abstract. IT governance is concerned with the governance, including the performance and risk management, of information and communication technology (IT). Considering the interest of all involved stakeholders, it may be seen as a set of concepts for ensuring a best possible utilization of IT for the benefit of a business. While many businesses, even in the service industries, are using related IT governance tools, a specific focus of certain areas in the service industries seems often lacking necessary peculiarities. In this paper, we are concerned with the public transport domain as an important area in the service industries. We show that IT governance has not yet received the importance it should have and we provide a research agenda for changing this picture.

To be more specific, as an important part of a corporate governance, IT governance is claimed to circumvent specifying the decision rights and accountability framework to encourage desirable behaviour in the use of IT. With that, IT governance becomes an important part of information management (IM), at least if we go beyond common sense definitions as, especially, the following does where IM is defined as the purpose-oriented provision, processing, and distribution of the resource information for decision support, as well as the provision of respective infrastructure. Nevertheless, IT governance is not about making specific IT decisions but rather determining who systematically makes and contributes to those decisions. Note that IT governance is closely related to a proper understanding of digital transformation, refers to a broader process of transforming an organization or a network of organizations on different levels by making use of digital technologies and concepts.

Planning problems in public transport are usually classified into different types of problems depending on which impact they have, i.e., strategic, tactical and operational. However, IT governance for public transport companies is usually not explicitly considered despite the widespread changes regarding data availability and passenger information.
An IT governance framework has to guarantee that an organization makes the right operational decisions to implement the strategic choices of the board. Looking at public transport companies and associations, the use of IT seems to be incorporated into future trends in the area, although the comprehension regarding governance and policy changes is often far from reality. Technology leaps are expected but still seem to be in need of paradigm shifts. On the other hand, we observe changing trends regarding data availability, especially when recent developments and uses of GTFS and NeTEx are concerned (GTFS: General Transit Feed Specification, NeTEx: Network Timetable Exchange). Based on these innovations we set up a three-layer framework regarding information and data use, information systems and related infrastructure.

Keywords: Public Transport, IT Governance, Digital Transformation, Information Management

Friday, September 23, 12:00-13:30; Session: Public Transport

Group Consistent Dial-A-Ride using Adaptive Large Neighborhood Search

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Abstract. The dial-a-ride problem (DARP) consists of scheduling and routing vehicles such that all users will be picked up and delivered within their specified time windows. Each user or customer has a pick-up location and a delivery location and has a time window that specifies the earliest pickup time as well as the latest delivery. Furthermore, the problem must consider the capacity constraints of the vehicles. A real-life example of the DARP is the transportation of school children to and from school, which is a service offered through the municipality to selected children. Varying the driver, driving time, and other passengers can be stressful - especially for children. This work considers the Group Consistent DARP (GC-DARP) which seeks to ensure that each user drives with a limited amount of different users. In this formulation of the GC-DARP, all users have some schedules. A schedule is one or more travel requests (with a defined pickup, delivery, and time window) that have a known set of repetition - i.e. weekly, every other week, once every 4 weeks, etc. The schedule can at maximum consist of an outbound and inbound travel request each day, depending on whether or not a return trip is desired. The problem must then not only consider trips with proximity in both time and location, but also the consistency and frequency with which the trips will be driven. We use the Adaptive Large Neighborhood Search (ALNS) to solve this problem for instances with up to 200 different schedules and schedule repetitions up to every other week.

Keywords: Vehicle Routing, Ride-Sharing, Dial-a-Ride-Problem

Production

Friday, September 23, 12:00-13:30

Chair: Steffen Rudert

1 **Multi-shift Worker Assignment Problem with a Heterogeneous Workforce in Semi-Automated Electronics Production.** *Nadine Schiebold*

2 **Heuristics for Single-Item Dynamic Lot-Sizing with Rework of Internal Returns.** *Steffen Rudert and Udo Buscher*

Friday, September 23, 12:00-13:30; Session: Production

Multi-shift Worker Assignment Problem with a Heterogeneous Workforce in Semi-Automated Electronics Production

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Abstract. To face the challenges of today's competitive industry, this work studies a real-world problem in semi-automated electronics production. It considers a worker assignment problem with a heterogeneous workforce in the multi-shift environment of protective device manufacturing. Simultaneously with multi-skilled workers, requested orders are assigned to workstations and shifts. One of the main particularities is the restriction of possible assignments of workers and orders to workstations according to qualifications. Additionally, this paper considers sequence-independent family setup times, disparate workstations, and a time limit for completing the orders. A mixed-integer linear programming model is introduced that minimizes the makespan calculated by the last shift used for production. The model is tested using real-world data. Additionally, this contribution examines the influence of the workforce with the help of scenario analysis and solves 49 test instances. The solutions serve as input and support for production planners and personnel planning. Furthermore, this work reveals production problems such as a lack of workers and qualifications.

Keywords: Worker Assignment, Heterogeneous Workforce, Multi-Shift Semi-Automated Production

Friday, September 23, 12:00-13:30; Session: Production

Heuristics for Single-Item Dynamic Lot-Sizing with Rework of Internal Returns

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Abstract. While external product returns from customers are well-studied in the dynamic lot-sizing literature, the same is not true for internal returns resulting from imperfect production. We approach this problem by considering a basic dynamic single-product lot-sizing model in which some of the items produced do not meet quality requirements and, therefore, must be reworked. The objective is to minimize the sum of setup and inventory costs for new production and rework while fully satisfying demand. To this end, three heuristics are developed, based essentially on two production policies that coordinate new production and rework. The resulting two policies are able to control the interaction between new production and rework in such a way that different parameter constellations are considered very well. This is confirmed by a computational study in which the developed heuristics yielded highly competitive results compared to those obtained with a commercial solver.

Keywords: Dynamic Lot Sizing, Defectives, Rework, Heuristics

Dispatching

Friday, September 23,12:00-13:30

Chair: Bibianda Granda

1 **Optimized Dispatch of Fire and Rescue Resources.***Tobias Granberg*

2 **Orienteering Problem for Fire Suppression.*** *Bibiana Granda, Begoña Vitoriano and José Rui Figueira*

Friday, September 23, 12:00-13:30; Session: Dispatching

Optimized Dispatch of Fire and Rescue Resources

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Abstract. A dispatching problem for fire and rescue services is considered, where firefighters have to be allocated to vehicles, and vehicles dispatched to an emergency. A mathematical model for the problem is formulated, capable of managing multiple alarm plans for each emergency considered. The model is solved both exactly and heuristically, using input data from a fire and rescue service area in Skåne, Sweden. The results show that the exact solution method might be too time-consuming in some cases, but that the heuristic in most cases finds the optimal solution.

Keywords: Emergency Logistics, Optimization, Heuristics, Fire and Rescue Services

Friday, September 23, 12:00-13:30; Session: Dispatching

Orienteering Problem for Fire Suppression

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Abstract. Wildfires are recurrent natural disasters that are increasing in frequency and severity over the last decades. They threaten human lives and damage ecosystems and infrastructure, leading to high recovery costs. To deal with them, several activities must be managed and coordinated to develop a suitable response that is both effective and affordable, considering the resources available and the safety of the personnel involved. This includes actions taken before (mitigation, prevention, and preparedness), during (response) and after the event (recovery). In the response phase two main problems can be distinguished: deployment and dispatch of resources.

The dispatch of resources is an activity that should be managed in real time under great pressure and with accuracy to avoid losses or engagement in dangerous activities. Thus, the possible strategic solutions should be developed in a short time but should be also suitable considering the current conditions of the fire.

Such difficult and quick decisions can be supported by operations research which provide useful tools to consider several aspects simultaneously.

The movement of the fire can be accounted for using data from simulators that describe fire behaviour, and the possible strategies can be modelled and optimized by mathematical programming. The difficulty of the problem resides in the simultaneity of fire behaviour and fire suppression, which affect each other, the challenge is to find the optimal suppression strategy while accurately modelling the fire spread.

This problem can be seen as a variant of the orienteering problem, which could be named as Team Orienteering Problem with Variable Time Windows. It is a team orienteering problem because several teams or brigades may be engaged in the suppression of the fire, controlling different fire spots. And it has

variable time windows because the control of these fire spots is subject to the fire arrival time, which can be modified by the suppression decisions.
Several authors have addressed the problem of integrating fire behaviour and suppression affecting each other (Wei et al. 2011, Alvelos 2018), but only some of them account for the actual design and timing of the suppression strategy in detail (Belval et al. 2019). In this study the possibility of applying the theoretical concept of the team orienteering problem is addressed in order to take advantage of the already developed resolution techniques.

Keywords: Fire suppression, Optimization, Mathematical Programming, Orienteering Problem

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