8th International Conference on Computational Logistics

BOOK OF ABSTRACTS AND KEYNOTES

UNIVERSITY OF SOUTHAMPTON

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Keynotes

Digital Transformation in Seaports – Old Wine In New Bottles?

Stefan Voss

Digital transformation is of utmost importance in the business world with major impacts on any of its sectors. Maritime shipping with seaports at its core is no exception. As actors in world-wide supply chains, seaports are particularly affected by technological change and innovation. Due to the high requirements in the logistics sector, e.g., regarding costs, efficiency, security, and sustainability, digital innovation is essential to stay competitive. Past developments show how digital innovation can shape the modernization of ports. In order to understand future challenges in this area, we review the outcomes of past developments and their impact on port operations. That is, we provide an extensive analysis of digital transformations in seaports. Based on our observations, we identify important aspects and challenges. Our analysis shows that in many (most?) cases the technology (and the data) was and is there; it just needs to be applied.

Planning Models and Methods for City Logistics

Teodor G Crainic

City Logistics is a vision for a better way of moving freight into, out of and through our cities, where "better" means aiming simultaneously for, on the one hand, the economic efficiency and profitability of the transportation and logistics industry, its customers and the city in general and, on the other hand, active support for the social development of the city and higher living conditions for its citizens through reductions of negative impacts on the environment, traffic conditions, safety, etc. City Logistics thus encompasses a number of innovative concepts, business and organizational models. The consolidation of shipments into the same vehicles, irrespective of the commercial transactions that generated them, and some form of stakeholder coordination/collaboration are at the core of most proposals. Two-tier systems are generally considered for medium and large urban zones, where shipments inbound for distribution within the city are first consolidated at main facilities on the outskirts of the city, moved to smaller satellite facilities close to the city-logistics controlled zone, where they are transferred to usually "green" vehicles of appropriate dimensions for the zone providing the final last-km distribution. Such City Logistics systems belong to the class of consolidation-based transportation, and require advanced planning methods to achieve their economic and societal objectives. We focus on the tactical planning problem of two-tier CL systems in this talk. We discuss the issues, the problem setting, and a general modelling framework. Uncertainty issues are addressed, together with their representation handling within this framework. We then present in some detail new developments that integrate several features, rarely considered previously, e.g., multiple transportation modes, including non-truck ones such as rail- or water-based; heterogeneous fleets with potentially several compartments per vehicle; and two types of transportation demand, i.e., inbound for distribution within the city and outbound to be picked up within the city and delivered at a main facility for long-haul movements. An algorithm based on Bender's decomposition has been developed for the formulation, yielding a series of managerial insights. We conclude with a number of challenging research perspectives.

Gnewt and the practicalities of the delivery operations in London

Sam Clarke

This talk will describe the journey that Gnest have experienced in the last 8 years of trading, the challenges that the urban area creates, and the need for 'smart' logistics to work in unison with the practical operational constraints in urban areas.
Abstracts
Benders Decomposition
for the Multi-Period Sales Districting Problem

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In the sales districting problem, we are given a set of customers and a set of sales representatives in some area. The customers are given as points distributed across the area and the sales representatives have to provide a service at the customers’ locations to satisfy their requirements. The task is to allocate each customer to one sales representative. This partitions the set of customers into subsets, called districts. Each district is expected to have approximately equal workload and travelling time for each sales representative to promote fairness among them and the overall travelling distance should be minimal for economic reasons. However, the real travelling distance is often hard to calculate due to many complicating factors i.e. time windows or unexpected situations like traffic jams resulting in a loss of service. Therefore, one of the alternative ways is to approximate the travelling distance by considering geographical compactness instead.

We now extend this problem to be more realistic by considering that each customer requires recurring services with different visiting frequencies like every week or two weeks during the planning horizon. This problem is called the ‘Multi-Period Sales Districting Problem’. In addition to determining the sales districts, we also want to get the weekly visiting schedule for the sales representative such that the weekly travelling distances are minimal and the workload and travelling time are balanced each week. Although the problem is very practical, it has been studied just recently. In this presentation, we focus on the scheduling problem for one sales representative in a specific district, which is already an NP-hard problem. We start by proposing a mixed integer linear programming formulation. Afterwards, we develop and implement a Benders Decomposition to solve the problem, exploiting the structure of the formulation. We also consider modifications of the method to enhance the performance of the algorithm.

Keyword: Mixed integer linear programming, sales districting problem, multi-period, Benders Decomposition
A Biased-Randomized Heuristic for the Multi-Period Vehicle Routing Problem with Flexibility in Delivering

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Abstract

The multi-period vehicle routing problem (MPVRP) (Francis et al., 2008) is an extension of the well-known vehicle routing problem (VRP) (Toth & Vigo, 2014; Caceres-Cruz et al., 2015) in which customer demands have to be delivered in one of several consecutive time periods, e.g., the days of a week. As observed by Archetti et al. (2015), in many practical settings there may exist some flexibility in the service time and effectively exploiting that flexibility may result in significant cost savings. Therefore, we study a variant of the MPVRP in which a service provider offers a price discount in exchange for delivery flexibility. More specifically, we consider a setting in which customers place orders to be delivered during a planning horizon consisting of several consecutive days. Each customer specifies a demand quantity, a delivery location, and a preferred delivery day. The service provider offers a discount to its customers in exchange for flexibility in the timing of the delivery, e.g., the delivery is allowed to be made one day early or one day late, i.e., one day before or one day after the preferred day. Essentially, this is a form of collaboration as both parties benefit: a customer benefits directly by receiving a discount, and the service provider benefits indirectly by being able to exploit the additional flexibility to reduce distribution costs.

Settings in which delivery flexibility is provided in exchange for a price discount are becoming more common as such agreements are found in many provider-customer contracts. This may be due, in part, by the changing landscape of city logistics (Savelsbergh & Van Woensel, 2016). City councils encourage (or force) service providers to reduce the number of trips into the city, which may be achieved by serving customers in the same district/region in a single trip. Delivery flexibility is required for service providers to do so. To the best of our knowledge, no other studies have dealt with this “pricing for delivery flexibility” setting. The goal in this initial study is to answer the following question: how much can total costs be reduced for different levels of delivery flexibility and different levels of price discounts?

To solve instances of this MPVRP variant, we propose a two-stage algorithm that combines iterated local search (ILS) (Lourenço et al., 2010) with biased-randomization (BR) techniques (Grasas et al., 2017). The
algorithm will be shown to work well (i.e., producing near optimal solutions) in a variety of settings, from the most restricted setting, in which a customer can only be served on his preferred day, to the most flexible setting, in which a customer can be served on any day. As a consequence, we are able to establish, for an instance, the total costs as a function of customer flexibility (and for different price discounts) and, thus, provide valuable insights into the potential benefits of pricing for delivery flexibility.

To summarize, the main contributions of our research are threefold: (i) we introduce a new, but, in our view, relevant variant of the MPVRP, which allows the study of pricing for delivery flexibility; (ii) we propose a two-stage BR-ILS algorithm to solve instance of this MPVRP variant; and (iii) we analyze the relationship between delivery flexibility and distribution costs, extracting valuable managerial insights.

Keywords: vehicle routing problem, multi-period, price discounts, biased-randomized heuristics, iterated local search

References


A heuristic decomposition based on column generation approach for combining orders in inland transportation

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1 Abstract

The inland transportation takes a significant portion of the total cost of the intermodal transportation. In addition, there are many parties (shipping lines, haulage companies, customers) who share this operation as well as many restrictions that increase the complexity of this problem and make it NP-hard. It is important to create an efficient management and planning to reduce the cost and the overall emissions and congestion that is caused by this problem. Unlike the traditional transportation management systems, nowadays many techniques and strategies are created and still under development to overseeing the planning of the problem. In this paper, we design a Mixed Integer Programming (MIP) model for combining orders in the inland transportation. In this MIP model, the pick up and delivery of both 20 and 40 foot orders from the terminals to the customers and vise versa is considered. The most important constraints such as the time window of orders, the weight of containers for a single and double trips, arrival time of orders at the final destination and the regulation of the working time are considered. A particular issue of this complex model is its capability to solve efficiently the problem in such case with up to 100 orders. To deal with large instances of the problem a decomposition and aggregation heuristic approach is designed. The basic idea of this approach is to decompose the locations of orders geographically into sub-areas based on the angle of the order location to the port and solve the sub-area fan-shape problems by using the formulated MIP model to achieve the solution of each subproblem. To balance the fleet size amongst all subgroups, column generation is used to iteratively adjust the number of allocated trucks according to the shadow-price of each truck type. In order to reduce the problem size and to improve the cost obtained from the initial decomposition, orders are aggregated in the next phase by removing the “best” combined orders and resolve the rest of orders. This decomposition and aggregation approach is tested and proven to be both efficient and cost-saving.
The Tugboat Scheduling Problem with Congestion

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Container terminals and seaports in general can face congestion periods that result in several vessels waiting to be berthed. The congestion can be due to force majeure that restricts the port use for a period of time or simply due to a high vessel arrival rate with limited port capacity. Nevertheless, it is favorable to berth the waiting vessels as fast as possible to increase turnover at the port and increase customer satisfaction. The berthing process mainly requires the below resources: Tugboats, Pilots, Pilot boats, and Mooring teams.

The tugboats are necessary for assisting the vessel in steering inside the limited area of the port, while a licensed pilot joins the vessel captain on board. If the vessel captain has the port navigation license, then the vessel is exempted from requiring a pilot from the port’s side. The vessel starts initially without the assistance of the tugboats and they join when it approaches a certain distance from berth location. Pilot boats transfer the pilots from and to the vessels. Finally, when the vessel reaches its berth location, the pilot and tugboats can leave the vessel and it is moored by a mooring team. Safety constraints also limit the operation where consecutive vessels must be separated with a minimum required distance.

Berth resource scheduling is different from the typical berth allocation models that study the assignment of vessels to berth locations. The literature of berth allocation is plentiful and a well-established survey by Bierwirth & Meisel (2015) can be visited. However, the literature in scheduling the resources required in berthing is scarce. Zhang et. al (2016) tackle vessel traffic control in a channel to minimize delay, however they assume tugboats and related resources to be available without shortage. In another research, Wang et. al (2014) study tugboat assignments to vessels where the tugboats have different horsepower, however they do not consider the other resources required in the berthing process.

In our work, we aim to use mathematical modeling to solve the tugboat scheduling problem by presenting a Mixed Integer Linear Programming (MILP) formulation. We aim to minimize the total berthing time by minimizing the berth completion time of the final vessel. Large-sized problems will be solved using an enhanced branch and bound algorithm.

The model under study is designed to assist port managers in berthing vessels in congestion periods. It assumes that all tugboats have equivalent horse power and thus tugboat allocation across vessels becomes trivial and can be identified by simple calculations. When this assumption is relaxed the integration of berthing recourses and tugboat allocation in mathematical modeling becomes worthy and this is the target of our future work.

References


Station Level Refinement of Train Unit Network Flow Schedules

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Abstract: Train unit scheduling at the network level focuses on vehicle flows to cover a timetable satisfying seat demands at minimum operational costs. Train stations are simplified to single points ignoring tracks and platforms. Where a trip is covered by coupled train units, the coupling order is also left undetermined. In this paper, the train station simplifications and unit coupling orders are addressed to refine a network flow schedule with added operational plans at the station level.

1 Introduction

Train unit vehicles have to be scheduled at both the network and station level once the train timetable has been determined. Usually, these two levels are treated as individual scheduling problems [1, 2]. This paper connects the two levels together and mainly focuses on the train unit shunting at the station level to resolve a network scheduling solution given by the two-phase approach [3] which first schedules the train units as a network flow problem without considering detailed station constraints. A branch-and-price method [4, 5] is proposed to solve the flow level of assigning limited units to prescribed train trips (trips). Its solution yielded is a unit-type assignment for each trip and the tentative linkages between arrivals and departures. Two operational aspects are left open to be determined at the station level. The first aspect is the unit coupling order in a trip served by multi-units, which has no impact on the network flow but must be finalized at the station level to prevent blockages. The second aspect is the precise conflict-free shunting movements for implementing the linkages between arrivals and departures.

2 Feasibility of Shunting Plans

The method of operating a linkage can be called a shunting plan. An individual shunting plan is feasible if it is operable within the permitted time, which can be checked by the duration of its corresponding tentative linkage. A feasible shunting solution means a group of shunting plans which can schedule all the units without conflicts between any two shunting plans. A shunting plan is affected by station layouts and unit coupling orders because it may involve a series of operations such as coupling and decoupling, reordering shunting, reverse shunting, platform transferring, siding shunting and this is a time-consuming process.

The tracks (platforms and sidings) have distinct approaching methods: a dead-end track can only be approached from one side but a free track can be approached from both sides. Obviously, different types of track lead to distinct shunting plans, which means they consume different amount of time. For example, suppose there are two possible shunting plans to implement a tentative linkage according to station layouts, but only one may be feasible because of the given shunting time. On the other hand, the unit order may lead to different shunting plans if coupling or decoupling operations are involved. For instance, a trip served by two units (front and rear) of different types arrives at a dead-end platform, and these units will serve two different departure single-unit trips. If the timetable and tentative linkage indicate the rear unit must leave before the front unit, it is feasible; but if the front unit must leave before the rear unit, then an extra shunting movement is needed, which requires more operational time than the first case. Moreover, the units staying at the station at a certain time share capacity-limited tracks. Hence, an individual shunting plan is not independent of other shunting plans, e.g. if two shunting plans corresponding to two linkages occupy the same track at the same time and the capacity of this track is not available to park two of them, the shunting solution with these two shunting plans are infeasible.
3 Combinatorial Problem and Solution Approach

In this paper, we mainly focus on how to refine the flow-level solution at the station level particularly in the aspects of linkages and the order of coupled units. In other words: given a timetable which describes the arrival and departure times and platforms, the flow-level solution as well as the layout of stations, how can the tentative linkages and the unit positions in the multi-unit trips be finalized? The flow level optimizes the unit-type assignments for the trips and tentatively links arrivals to departures. For a tentative linkage, there may be many different ways to implement it according to the layouts and the unit positions in multi-unit trips, leading to a very large number of possible shunting plans. Thus, a tentative linkage corresponds to a set of potential alternative shunting plans. For each tentative link, only one potential shunting plan can be selected for real-world operation. Usually, a large number of linkages are operated on a rail network containing many stations. Selecting one potential shunting plan for each linkage forms a shunting solution. Obviously, this is a huge combinatorial problem.

For this problem, the most straightforward method is brute force enumeration. All possible shunting plans for all linkages and all possible unit coupling orders should be enumerated firstly and then check the compatibility between any two shunting plans. The combinations are likely to be out of control. According to the empirical shunting of real world, a shunting plan is usually operable if there is enough time. Therefore, we propose an approach of narrowing down the problem size by estimation first and solve the remaining problem with precision. Firstly, we categorise different scenarios according to the possible operations implied by a linkage. For each scenario, an estimated operational time is set according to the real-world operational principles. If a linkage duration is below the required time, this linkage is physically unworkable, and this infeasibility has to be resolved. A long duration tentative linkage would be feasible for the station-level operation because there is likely a method to shunt them. The linkages whose duration is just slightly longer than the minimum required must be scrutinised. They are the most critical tentative linkages on this railway network. These critical tentative linkages will be assigned with the precise shunting plans and coupling orders. Under the precondition of guaranteeing those restrictive shunting plans and fixed coupling orders, the impact of these restricted links on the other links will be analysed. If any unworkable shunting plan corresponding to a specific linkage or a certain unit order shows up, this negative feedback will be resolved.

4 Remarks

Our research in this paper is ongoing. Experimentation with real-word data and the latest results will be presented during the conference.

Acknowledgements

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References


Stock keeping unit assignment to unidirectional picking lines

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ABSTRACT

An order picking system in a retail distribution centre (DC) operated by PEP Stores Ltd. (PEP), located in South Africa, is considered. PEP predominantly sells apparel and the DC considered here services about 1800 stores. A central planning office releases batches of stock keeping units (SKUs) that differ only in size. These batches are called distributions (DBNs) and are continuously released to the DC to pick and ship to the stores. A DBN thus contains one or more SKUs together with the instructions of how many of each of the SKUs in that DBN should be sent out to each store receiving that SKU. Each DBN also comes with a deadline in the form of an out-of-DC date. SKUs in a DBN must be kept together throughout the order picking process to ensure that all the sizes of a product arrives at the same time at the stores.

The order picking system consists of parallel unidirectional picking lines. Order picking happens in waves. A wave of picking implies that a set of DBNs is assigned (and physically taken) to a specific picking line. A team of pickers then pick all the SKUs on this picking line for all the stores. Once all the SKUs are picked (and leftover stock, if any, are removed) from the picking line, the picking line is populated with a new set of DBNs to start a new wave of picking. The decision of which DBNs to group together in a given wave of picking has a major impact on the efficiency of the order picking process.

In this presentation we consider the question of which DBNs to assign to which picking lines during a wave of picking on a given day and which DBNs should stand over for a following day. The objectives considered during this assignment are to minimise

1. the walking distance of the pickers, i.e. the number of cycles traversed on all picking lines by all pickers,
2. the volume of stock on the picking line (during a wave of picking) with the largest volume of stock to ensure work balance of waves of picking,
3. the number of packages whose volume fail to exceed roughly the size of a shoebox and
4. the total penalties incurred to DBNs for not being assigned to a picking line before a specified out-of-DC date.

The problem may be modelled as a multi-objective multiple knapsack problem where the picking lines may be viewed as the multiple knapsacks and the DBNs as the items to be inserted into the knapsacks. Due to the size of real life problems exact solution approaches fail to solve this model. Population-based metaheuristics, like the genetic, artificial bee colony and memetic algorithms, were implemented to approximate the Pareto frontier for the first two objectives.
while utilising penalty functions to handle the last two objectives. The last two objectives were handled by means of penalty functions to keep their values within user defined limits.

The proposed algorithms were tested on real historical data received from PEP. All algorithms were able to improve on historical assignments used by PEP. However, the genetic algorithm performed the best in both the static and dynamic cases. The genetic algorithm showed an average decrease of 23.64% in the walking distance of all the pickers and a 34.97% decrease in the volume of stock on the picking line with the largest volume of stock. The percentage of small packages was maintained while on average a 20% decrease in the average number of days that DBNs are assigned later than their out-of-DC date was achieved.
On Fair Facility Location Problems 
in a Supply Chain

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Keywords: Facility location; fairness; equity; conditional mean minimization.

We consider a plant location problem where a supplier will be locating facilities to serve a set of customers. We assume that the location costs are in charge of the supplier, whereas each customer pays the transportation costs between its position and the serving facilities. This situation, common in public services, may also be associated with a supply chain environment, e.g., in the location of franchise retail stores and the location of collection points in reverse logistics systems. For a supplier, an effective service is expressed by two goals: the facility location cost and the customer satisfaction [5]. While the first goal is easy to formulate uniquely, the second one can be characterized in different ways. In this work, we assume that customer satisfaction is a matter of both fair allocation of transportation cost (system equity) and minimum total transportation cost (system efficiency). System efficiency can still be formulated in an obvious way, whereas many different measures of system equity may be proposed [3]. We argue that equity is well captured by the minimization of the conditional \( \beta \) mean of the transportation costs, i.e., the average unit transportation cost paid by the \( \beta \) percent of the total demand paying the highest costs [4].

After discussing the nice properties of the selected measure, we embed the conditional \( \beta \) mean in the Single Source Capacitated Facility Location Problem (SSCFLP), obtaining a bi-objective MILP model, where the first objective is the total location cost (plus a scaled total transportation cost), and the second objective is the conditional \( \beta \) mean of the transportation cost. To test the relevance of the adopted measure, we build a small representative set of the Pareto front on a set of 163 benchmark instances of the SSCFLP ranging from small to large size [1, 2], using different values of \( \beta \). The experiment reveals the ability of the bi-objective model to capture good compromise solutions with a moderate increment in the computational effort, at least for small/medium size instances. We also test alternative models where the conditional \( \beta \) mean is replaced by more common measures, like the maximum unit cost.
(Minimax), the Mean Absolute Deviation (MAD), and the Range. The conditional β mean appears to be more flexible than the Minimax and easier to optimize than the MAD and the Range. Moreover, the minimization of the conditional β mean also controls the other tested fairness measures.

Future developments include:

- the design of algorithmic tools to tackle efficiently large instances;
- the relaxation of the single-source constraint in the location model.

References


Implementation and Performance Measurement of a Value Stream Oriented Organizational Structure: A framework proposal

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Keywords: Value Stream Management, Performance Measurement, Organizational Structures

Abstract: The increased competitiveness, caused by the volatility of today's markets, has been pushing organizations to innovate in terms of leadership and management models. To maintain a sustainable market share, organizations must provide high-quality, cost-effective and affordable products in the shortest time possible. Organizational survival and growth depend on the agility, flexibility and robustness of Supply Chains in an increasingly demanding market. Organizations should seek to break down the most common organizational paradigms, through fundamental values such as the efficiency and empowerment of individuals. Through an application of the Action-Research Methodology, this study provides a proposal for a roadmap of activities to implement a management model oriented according the Value Chain. Additionally, it presents results of an application in a real organizational context and provides a better understanding of the impact that the Integration of the Supply Chain has on the organizational performance.

1. Introduction
The need to be competitive and to obtain higher levels of customer satisfaction, are factors that have been encouraging today's companies to change their organizational paradigms. Differentiation should be based on an increase in the speed, quality and delivery of products and / or services to the markets, allowing a more efficient and effective management of Value Chains. In today's business environment, we are faced with conservative management models mainly supported by a defined structure. These, are based on standard processes and focus on the achievement of lean results, with high levels of excellence and maturity. However, the constant technological evolution has brought with it a set of new possibilities that have been forcing organizations to rethink their management and leadership models. We thus entered a new era, where a new approach to the most common management concepts emerged. Influenced by the need to innovate, companies must redefine their management strategies, establishing connections between their organizational structures and Value Stream concepts, with a multidisciplinary view of Supply Chain processes. Looking at the Value Stream of an organization is looking at the set of activities needed to produce a new product or deliver a new service to the customer, whether they add value or not. In a Value Stream, the goal is to achieve maximum levels of customer satisfaction. Thus, the main requirement to ensure, is the total quality of products, processes and services. The importance of looking at the Value Stream from a global perspective, rather than looking at individual production processes, has become increasingly clear to organizations in the pursuit of excellence. A Value Stream always ends with the end consumer, which can be internal (from functional area to functional area), or external. This factor assumes a high impact on Value Streams complexity. High degrees of complexity may have implications for the overall Value Stream performance, so segmenting complex Value Streams into simpler Value Streams is a valid option and should be adopted by organizations, to add more value to its customers. This study aims to provide strategic decision makers and top managers with a tool to support the implementation of a Value Stream Oriented Management Model in an organization. Therefore, we propose a framework. To this end, an action roadmap has been defined, which can be deconstructed into several steps, which we consider to be fundamental for a successful implementation of the model. Additionally, a Performance Measurement model is presented throughout the framework, identifying the key aspects of Supply Chain Performance. The results of this work are validated through a case study of a real company.

2. Objectives and Methodology
The research process lasted eight months, during which, several theories and concepts related to the Supply Chain Integration processes and Process Management models were reviewed. To be sustainable, the tool was justified and tested by means of a practical case study, using a Research - Action (RA) method. The case study aims to support the construction of the framework, exposing the difficulties and positive and / or negative aspects experienced in the business reality. The RA process was, therefore applied to the construction of the framework and structured within the scope of the company's business reality. Topics such as Supply Chain Management have been a constant target of several studies over the last few years. However, there is still relatively little literature that establishes a linear relationship between concepts...
such as Supply Chain Management and Value Stream. What is missing from the perspective of the most of the existing literature, is a simple step-by-step guide for the various phases of the implementation of management models, that could provide organizations with the necessary resources to add value to their clients. Therefore, we intend to fulfill this gap, by presenting a roadmap that was conceived as a resource for professionals at all levels of the organization. The framework intends to support the understanding of the various phases involved in the implementation of the Value Stream management concept. The implementation can be approached in two ways: the first refers to the transformation / transition from a functional management concept to a management model by Value Stream; The second concerns the root implementation. To this end, the roadmap was compiled in the following steps: (1) Expectations Alignment; (2) Project Scope Definition; (3) Management Model Design; (4) Organizational Structure Definition; (5) Human Resources; (6) Functional Interface Definition; (7) Implementation and Start of Production; (8) Performance Measurement; (9) Continuous Improvement.

3. Results
From the case study implementation roadmap, several aspects were concluded. The implementation of the Value Stream model in the business reality of the studied company, represented an important step in the innovation process of the management paradigm of the entire organizational structure. Strong belief was taken that, to achieve results more quickly and effectively, teams should be empowered to take decisions autonomously and with greater levels of customer proximity. In terms of innovation, the radicalism associated with the new approach to the existent management and leadership concepts, brought a high degree of complexity, which had to be carefully handled by the drivers of change, throughout the implementation steps. Additionally, it was concluded, that from a Value Stream model implementation, several organizational benefits should be expected, such as: Significant increase in organizational efficiency; Significant increase in terms of empowerment of individuals; Increased proximity levels of the final customer; Response time to consumer needs reduction; Added value to processes; Significant cost reduction. The obtained results allow to conclude that the implementation process was achieved and successfully implemented. Management and leadership concepts, play a key role in Supply Chain performance, being responsible for offering competitive solutions in terms of quality, cost and delivery. The empowerment of teams is a key factor, in maintaining high levels of motivation which in turn, are directly related to results. The creation of value is empowered and the main value creators are held accountable in an organization.

4. Conclusion
The innovation of traditional management models is a necessary condition by leading organizations. The creation of structures that feed the interaction between the elements in a team, favours the establishment of information sharing interfaces and working methods, thus allowing the integration of the various processes in a Supply Chain.

5. References
How to load a ferry: a comparison of packing algorithms for the vehicle ferry industry

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Keywords: Vehicle ferries; packing; queue policies; dynamic pricing

The efficient packing of vehicles onto a ferry enables a company to sell more tickets, increase efficiency and, if combined with a suitable pricing policy, improve ticket revenues as well. In this presentation we will introduce and compare three approaches to optimizing packing of a vehicle ferry. 1. 1D bin packing (1DBP): this assumes that each vehicle is allocated to a lane on the ferry and no overlaps are allowed [A. Martinez-Sykora 2017]. 2. Simulation heuristic approach that simulates ferry loading and selects parking spaces following a loading rule that is optimized using simulated annealing. [Bayliss et al. WSC 2016] 3. Sequential Guillotine Cut Knapsack (SGCKS) approach, which allows for constraints on the solution due to the loading process and random vehicle arrival times. [Bayliss et al. ESICUP 2017] The work described here forms part of a wider project in which we incorporate packing into a dynamic pricing model. These methods use price as a lever for demand to encourage more efficient and profitable vehicle mixes. Versions of the first two approaches have been published elsewhere and so we will focus the presentation on describing the new approach (SGCKS). Each of the packing methodologies will be compared and contrasted in terms of the real-world constraints that they satisfy.

Problem Formulation

Vehicle ferries transport private and commercial freight alike. There is a large number of non-standard constraints to take into account in the vehicle ferry loading process. On departure day the vehicle ferry loading process begins approximately 15 minutes before the scheduled departure time. Vehicles arrive at random times before the beginning of the loading process. On arrival at the ferry terminal vehicles are allocated to a terminal lane based on vehicle type. The queues at the terminal constrain the packing problem as only vehicles that are at the front of a queue can be loaded next. Due to the random arrival times of vehicles the orders of the queues are uncertain. Due to the limited space for vehicle manoeuvres vehicles can only be parked in positions that they can drive into unobscured starting from the entrance. The vehicle ferry loading problem is also constrained by the layout of the ferry itself. Vehicle ferries can have numerous decks and some decks have mezzanine decks which can be lowered from the ceiling; these increase the ferry’s capacity for low vehicles whilst reducing its capacity for high vehicles. Vehicle ferries also have considerable weight distribution constraints to protect the stability of the vessel. The loading process also has vehicle type specific constraints. For example certain vehicles may require unimpeded access to the lifts at the side, others may have large turning circles which prevent them from being parked into corner positions beside the exit, vehicles with hazardous materials must be parked underneath sprinklers, parking gaps are required so that passengers can exit the vehicle decks for the duration of the journey and some customers pay an additional fee for priority boarding. 1DBP: By assuming that the ferry is divided into lanes and that vehicles can only be parked in lanes that are at least as wide as the vehicle then the packing problem can be modelled and solved as a 1D bin packing problem. This formulation is used to enumerate non-dominated vehicle mixes that form the Pareto front. The set of all vehicle mixes that fit onto the ferry are used as the states of the dynamic pricing formulation. The 1DBP model was also extended to allow for the possibilities of different sets of lanes with different widths and wide vehicles being parked across adjacent lanes. The 1DBP formulation accounts for spatial constraints in three dimensions by modelling the lanes as bins. Simulation Heuristic: This is a 2D packing heuristic in which vehicles are selected and placed in efficient positions, where efficiency is measured using a weighted sum of placement efficiency attributes. This process continues iteratively until all of the vehicles have been loaded or no more vehicles fit onto the ferry. The choice of the weights significantly affects the efficiency of the overall packing solution and we use a simulated annealing algorithm to search for the weights that maximize the overall packing efficiency. There are a number of advantages of this approach. First, the loading simulator automatically ensures that all of the constraints are satisfied by only generating candidate positions for vehicles in feasible positions. This includes allowing for practical constraints such as access to lifts, parking gaps between vehicles and turning circles. Second, the approach allows for 2D packing arrangements, which usually results in better solutions than those obtained from the 1DBP formulation. Third, for the pricing problem the approach remains tractable for larger numbers of vehicle types because the simulation is used to map the vehicle mix state to a lower dimensional remaining space state. In comparison with the 1DBP approach it was found that the simulation heuristic achieved an average 97.48% of the revenue attained by the 1DBP approach. However if the simulation heuristic uses the 2D packing heuristic the simulation heuristic achieved an average of 31.72SGCKS. The SGCKS approach aims to retain the advantages of the 1DBP formulation and a more general 2D packing framework.
whilst also allowing for the effect that terminal queuing processes and random vehicle arrival times have on the feasibility of a pre-planned packing solution. Packing solutions are constructed by performing guillotine cuts vertically or horizontally across the remaining deck space. After such a cut, one piece is packed as a 1D bin and the other is the remaining space for the next guillotine cut in the sequence. The approach allows for the effects of terminal queues and random vehicle arrival times as vehicles can only be added to a 1D bin if they are at the front of a queue at the given time. There are two main elements to a packing solution within this framework: the sequence of guillotine cuts; and the yard policy, which dictates which yard lane a vehicle will be allocated to when they arrive at the dock prior to boarding the ferry. We introduce an iterative metaheuristic algorithm that alternates between packing optimization and yard policy optimization, each time the other element is fixed. The objective is to maximise the ferry utilisation that can be achieved in practice in over 95% of cases. In packing iterations a set of efficient packing solutions are found for each of a set of random arrival scenarios (minor uncertainty set). Yard policy iterations search for efficient yard policies that increase the probability that at least one of the packing solutions can be implemented in each of a wider set of random scenarios (major uncertainty set). Experimental results show that this approach provides robust packing plans under random vehicle arrival times. It has also been shown that the number of lanes in the ferry terminal yard significantly influences the feasibility rate of any given packing plan. The advantage of this approach is that it retains the convenience associated with 1DBP models but also taps into the efficiency benefits that can be achieved through 2D packing solutions. The SGCKS approach also takes upstream uncertainties into account and provides a guarantee on the feasibility of the final solution. Neither of the two previous models allow for this. Additionally, we provide a lower bound formulation which highlights the quality of the packing solutions that can be derived using the SGCKS approach.
An Integrated Stochastic Location-Inventory Problem with Product Remanufacturing

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Abstract

In this talk we consider a closed-loop supply chain consisting of plants, distribution centres (DCs), remanufacturing centres (RCs), and customers. Plants produce goods that are transported to distribution centres and from thereon to the customers. Customer demand is assumed to be normally distributed with known mean and variance. Goods can be stored at distribution centers and we assume that a stochastic inventory policy with type 1 service levels is used. Moreover, we consider the case that customers return a certain percentage of goods. These returns are shipped to remanufacturing centres and then fed back into the forward supply chain as being “as good as new”. The goal is to determine the number of DCs and RCs to be constructed and their locations, the allocation of customers to DCs and RCs as well as of RCs to DCs, and the safety stock levels and order quantities for DCs such that the overall logistics costs are minimal.

We present a second order conic programming formulation for the problem and a computational analysis. We are especially interested in finding answers to questions like: How much better is an integrated approach compared to a sequential location-first-inventory-second approach? Or how robust are solutions with respect to changes in the parameters, especially customers demands and returns?

Keywords: Supply chain design, facility location, stochastic inventory management
Optimization of Inter-modal Rail Transport in a Port Area

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Introduction

Traditionally, thanks to its flexibility, cost and reliability, road transport is more frequently used in container transport than other transport modes like railway and inland waterways. However, railway transport usually consumes less energy, which means the transport can be cheaper and cleaner on longer distances. Therefore, inter-modal rail transport (IRT), which integrates advantages of multiple transport modes, is widely considered to be an efficient, cheap and environmental friendly way of transport.

Many researchers studied the relevant problems in different perspectives. Ottjes et al. (2007) develop a simulation model for several terminals in Rotterdam port and test the traffic flow between the them. Tierney et al. (2014) propose a fully defined mathematical model of inter-terminal transport (ITT) using a time-space graph. In terms of railway terminal operations, Boysen et al. (2013) present an exhaustive review of railway terminal operational problems and challenges. Much research has focused on the train loading and unloading problem, e.g., Corry and Kozan (2007) propose an assignment model for dynamically assigning containers to slots on a train at an inter-modal terminal.

Previous research has mainly focused on either the ITT or terminal operation part, while neglecting the integration of different segments. In order to provide the IRT service in port area, both transport and transshipment operations should be carried out inside terminal and between terminals. If an intermodal terminal is connected to multiple transport accesses, e.g., railway tracks and truck drive ways, the container can be transferred from other transport modes to railway inside that terminal. Otherwise, the container must be moved to a railway terminal.

Therefore, it arises the following problem: how to organize the container transport from deep sea terminals to the hinterland through different terminals and transport modes. For example, when a maritime terminal receives an outbound container and plans to send it out by railway, the terminal operator must know how and when to move the container to a railway yard according to the timetable. While there is no railway yard inside that terminal, the terminal operator have to decide when and how to move the container to a dedicated railway terminal. At the same time, the railway terminal operator wants to know how many containers will arrive at what time, so that they could optimize the train loading operations and departure time. This is the motivation of our research.

In this research, we focus on the following research questions:

1) How to organize the ITT with road and railway when a limited number of ITT trucks and ITT trains can be used. When both transport modes are available, we want to optimize both
of the routes of vehicles and the handling operations such as loading, unloading and transshipment.

2) How to determine the formation and departure time of the train to hinterland under the condition of given time windows. When several railway terminals and several time slots are available, we try to find when and where a train should depart.

**Problem description**
To study the ITT with IRT, we first classify terminals related to IRT into three categories: railway terminal with road connection (RTR), maritime terminal with road connection (MTR) and maritime terminal with road and rail connections (MTRR). Then we identify four types of transport: ITT with trucks, inner terminal transport with trucks, ITT with trains and transport to hinterland with trains. Hinterland trains can depart from RTR and MTRR according to given time table. Additionally, we identify three types of handling operations: pick up, drop off and transfer. Pick up operations move container from the stacking blocks onto trucks and trains; drop off operations move container from trucks and train onto stacking blocks; transfer operations move container from one train to another. Based on this system, we study the movement of containers and vehicles with different transport demand and different railway time tables.

**Mathematical model and Computational experiment**
We use a time-space network to represent the container transport problem between several terminals. In the network, nodes denote different locations, and arcs denote the connection between locations. Therefore, the movement of containers and vehicles can be demonstrate by the number of containers and vehicles on different arcs.

Then we construct an integer linear programming model for the transport and transhipment operations. The objective of this model is to maximize the number of container transported to hinterland by trains. A network which includes 11 terminals is used as a test case. Using that test case, we optimize the container transport with a planing horizon of one day.

**Current works & Outlook**
We are now running the experiments with different transport demand scenarios and different railway timetables. We expect the result could indicate how trucks and trains could be used in ITT, where the transshipment operations should be performed and how to determine the trains’ formation, departure time and departure terminal.

**Reference**
The supply chain 4.0 and supply chain collaboration: a case study

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Keywords: Chain 4.0; Supply Chain Collaboration; Emerging Technologies, Case Study

Abstract: In the current era digital technology is becoming to have major impacts on the supply chains and on the way they perform business and interact along the supply chain. The Internet of Things, big data analytics, cloud computing, Augmented/Virtual Reality, 3D printing, and robotization are expected to have huge impacts on the supply chain performance. The big question is how digital technology can make part of a truly integrated and re-designed supply chain. So, in this paper we present a study concerned with the supply chain (SC) 4.0 influence on SC collaboration. To attain this objective a definition of supply chain 4.0 is provided, the main advanced technologies associated to it are presented and their influence on SC collaboration is explored.

1. Introduction
Supply chain management (SCM) is concerned with “having the right item in the right quantity at the right time at the right price for the right customer”\textsuperscript{2} (Malik, 2010). However, due to the complexity, uncertainty and other factors involved, most of the supply chains have many supply-demand mismatch problems such as overstocking, stockouts, and delivery delays (Wong et al., 2012). To deal effectively with the increasing challenges, supply chains must become smarter (Butner, 2010) and take full advantage of SC relationship and SC collaboration. Moreover, SCs can also reap benefits from improvements in areas such as: semiconductor, computer science, and other engineering technologies. The new version of supply chain seeks to establish a large-scale intelligent infrastructure for merging data, information, physical objects, products, and business processes together (Schuster et al., 2007). Despite the difficulties and complexities, SC 4.0 applications provide many benefits, such as: large amount of information can be collected and used to make better business decisions; better business processes could be developed to support higher efficiency and quicker response; the dynamic complexity could outstrip the possibility of human intervention to identify and solve many system issues; and can take out much of the persistent inefficiencies (Wu et al., 2016). Being so, it is harder to achieve performance improvements through the traditional means and companies clearly see the critical need to develop newer solutions arising from technology and business-model based innovations. Further, the costs of instrumentation have declined dramatically in recent years and smart devices are being deployed everywhere (Zhu et al., 2012). Computing and information technologies can now support widespread instrumentation, monitoring, and perform analytics. This study will contribute to a clarification on what constitutes a really SC 4.0 giving managers insight on the main advanced technologies supporting it. Also, the collaboration in this new challenged context is explored with a focus on technological issues that are changing the way individual companies and corresponding SC’s are collaborating with their partners.

2. Objectives and Methodology
In the light of emerging technologies, one concern of this research is to clarify the concept of supply chain 4.0 since there are other terms, such as smart supply chain, digital supply chain, e-supply chain (Akyuz and Relan, 2009), that have been used in several works (Wu et al., 2016) referring to SC 4.0. Also, there are a lot of automatic technologies supporting the supply chain 4.0 that are used across automotive SCs that we explore in the context of the SC collaboration. So, other important concern that justifies the development of this work is to analyse the influence of a SC 4.0 on SC collaboration. To attain the main objective of this work, i.e. to evaluate the role of a supply chain 4.0 to the enhancement of SC collaboration initiatives, a case study methodology was followed. According to Perry (1998) and Rowley (2002), a case-study approach is appropriate when the boundaries of a phenomenon are not only unclear but also there is no control over behavioural events. In this research, the boundaries (Influence of SC 4.0 on SC collaboration) are still relatively vague. Furthermore, at this early stage of research it is better to cover a specific supply chain (automotive Supply chain) to further refine the research methodology for future research.

3. Conclusion
In this work, deriving from a literature review, a set of advanced technologies are considered as making part of the SC 4.0 concept, such as: Internet of Things; Big Data; Cyber-Physical Systems, Cloud Computing, Collaborative Robots and Smart Machines. All these technologies influence the different types of SC collaboration considered by Cohen and Roussel (2005) contributing to foster the SC collaboration.
References
Quay Crane Scheduling for a Vessel by Considering Discharge and Loading Patterns

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Abstract

In this study, we consider the quay crane scheduling problem for a vessel by considering discharge and loading work patterns. There are multiple quay cranes and each job represents total amount of either discharge operations or loading operations of all the container in a hatch. The goal is to determine the optimal schedule of quay cranes that minimizes the makespan.

A container vessel consist of hatches. There are a discharge job and a loading job for each hatch, which are processed by quay cranes (QCs). In a hatch, the discharge job is processed first and the loading job is done next. For a QC to handle more than one hatch, it conforms to one of the following work patterns: hatch-wise, first-discharge, and same-direction. To illustrate the patterns, suppose a QC handles hatch 3, 4, and 5. Let $D_j$ and $L_j$ denote the discharge job and the loading job in hatch $j$, respectively. The handling sequences are (by supposing hatches are indexed from left to right):

- **Hatch-wise** The QC processes $D_3 \rightarrow L_3$, $D_4 \rightarrow L_4$, and $D_5 \rightarrow L_5$, in sequence.

- **First-discharge** The QC processes $D_3 \rightarrow D_4 \rightarrow D_5$ and $L_5 \rightarrow L_4 \rightarrow L_3$, in sequence.

- **Same-direction** The QC processes $D_3 \rightarrow D_4 \rightarrow D_5$ and $L_3 \rightarrow L_4 \rightarrow L_5$, in sequence.

We consider i) a job can be split and processed by more than one QC, i.e., preemption is allowed, ii) fractional job processing time is allowed, iii) a QC cannot cross each other, iv) two QCs cannot handle adjacent hatches at the same time to avoid interference, v) the hatch switch time (gantry travel time and setup time) of a QC is negligible, and vi) each QC may have the ready time and the deadline. The objective is to determine the optimal job split and job-processing schedule by QCs that minimizes the makespan, i.e., the maximum completion time of all jobs.
First, we present an exact, efficient algorithm based on a dynamic programming approach for the hatch-wise pattern where i) job split is not allowed, and ii) interference is ignored, i.e., two adjacent hatches can be handled by QCs at the same time. The time complexity of the proposed algorithm is asymptotically $O(n^2)$, where $n$ is the number of hatches.

Second, we show that there exists an exact algorithm with time complexity $O(n)$ for the hatch-wise pattern where the ready time and deadline is not allowed, i.e., all QCs are available over whole planning horizon. The results can be easily extended to some special cases of the first-discharge and same-direction patterns.

Lastly, for handling general cases, we propose a mix-integer programming model, based on the job precedence graph (e.g., see the figure below for first-discharge pattern) whose nodes represent jobs to be handled by QCs. We build the model as simple as possible for reducing the computation time, and the optimal but crude solution by the model is post-processed for fitting to the requirement of real operations of QCs. In addition, we find out the tight upper-bounds of the coefficients for implementing the logical conditions to curtail the computation time further. The experimental results show that the approach can be used for solving practical-size problems in container terminals.

The proposed approaches is expected to be effectively exploited for handling the higher-level problems, such as the QC scheduling problem for multiple vessels and the berth planning problem that includes QC assignment and scheduling, by considering the one-vessel QC scheduling as a subproblem.

**Keywords.** Container terminal, berth planning, quay crane scheduling

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Supply chain transportation plans optimization
Time-expanded graph enrichment heuristic

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Abstract. We address a problem of freight transportation in supply chains. To model flows over time in the system, we use time-expanded graphs. However, the time-expanded graphs’ size increases exponentially with the number of actors and the time dimension, which makes the industrial solvers inefficient to overcome real instances. To face this difficulty, we conceived an heuristic based from Boland’s and Hewitt’s Dynamic Discretization Discovery. We manipulate a partially time-expanded graph, composed of a small subset of nodes and arcs, and enriches it incrementally. We produce a sparse graph with the essential elements and solve the associated problem, with much less constraints and variables.

Keywords: supply chain, time-expanded graph, heuristic

1 Introduction

This paper describes a resolution algorithm for the computation of supply chains’ transportation and storage plans. We consider tri-echelon supply chain with suppliers, hubs and clients. Unfortunately, realistic instances in terms of network and time horizon quickly yield to problems too large to be sorted in a reasonable amount of time with an industrial solver. Boland and Hewitt \cite{1} addresses to a comparable freight transportation problem over time, the Continuous Service Network Design Problem (CSNDP), of which the static version was reviewed by Crainic \cite{2}. They conceived a ingenious method based on time-expanded graph enrichment to deal with the important data’s scale. The Dynamic Discretization Discovery (DDD) first generates an initial time-expanded graph constituted with a small subset of the nodes and arcs. Successively, the CSNDP is solved and the graph is enhanced until the reach of the optimal solution. Our works were drawn from this logic and led us to the following resolution heuristic.

2 Problem description

The supply chain can be represented with a time-expanded graph $D_T = \mathcal{N}_T, \mathcal{H}_T \cup A_T$ derived from the ”static” network $D = (\mathcal{N}, A)$. The set of nodes $\mathcal{N}_T$ is obtained duplicating the physical locations (suppliers $\in \mathcal{U}$, hubs $\in \mathcal{V}$, customers $\in \mathcal{W}$).
of \( \mathcal{N} \) through the time horizon. The set of arcs is decomposed into the holding arcs \( \mathcal{H}_T \) - connecting two occurrences of the same physical location - and the transportation arcs \( \mathcal{A}_T \). Each arc \( ((i,t),(j,t')) \) has a travel time \( t' - t \), a per-unit-of-flow cost \( c_{ij} \in \mathbb{R}^+ \), a fixed cost \( f_{ij} \in \mathbb{R}^+ \), and a capacity \( u_{ij} \in \mathbb{N}^* \).

Let \( \mathcal{K} \) denote a set of commodities, each customer has a positive demand of commodity \( k \) at time \( t \): \( d_{wk} \). So for each commodity we know the related sink \( w \), but no predefined origin - any supplier can ship any commodity. We define \( \text{SCNDP}(\mathcal{D}_T) \) to be our Supply Chain Network Design Problem with integer variables \( y_{ij}^{tt'} \) the resources required to route freight on an arc \( ((i,t),(j,t')) \), and continuous flow variables \( x_{ktt'}^{ij} \). The following is a generic valid integer linear programming formulation of this problem:

\[
\begin{align*}
\min & \quad \sum_{\mathcal{A}_T} f_{ij} y_{ij}^{tt'} + \sum_{\mathcal{K}} \sum_{\mathcal{A}_T} c_{ij} x_{ktt'}^{ij} + \sum_{\mathcal{K}} \sum_{\mathcal{H}_T} c_{ii} x_{kii}^{tt'} \\
\text{s.t.} & \quad \sum_{\mathcal{A}_T \cup \mathcal{H}_T} x_{ktt'}^{ij} - \sum_{\mathcal{A}_T \cup \mathcal{H}_T} x_{ktt'}^{jl} - \sum_{\mathcal{A}_T \cup \mathcal{H}_T} y_{ij}^{tt'} = 0 \quad \forall (j,t) \in \mathcal{V}_T, k \in \mathcal{K} \\
& \quad \sum_{k} x_{ktt'}^{ij} \leq u_{ij} y_{ij}^{tt'} \quad \forall ((i,t),(j,t')) \in \mathcal{A}_T \\
& \quad x_{ktt'}^{ij} \geq 0, \quad y_{ij}^{tt'} \geq 0, \quad \forall ((i,t),(j,t')) \in \mathcal{A}_T \cup \mathcal{H}_T, k \in \mathcal{K}
\end{align*}
\]

We seek to minimize the total expenses, i.e. the transportation costs and holding costs. Constraint 1 is an adapted Kirchhoff constraint, and Constraint 2 ensures that sufficient resource capacity is available for the commodities.

3 Method

Boland and Hewitt DDD is an exact method that solves the CSNDP with free holding costs for the commodities. It is based on the iterative refining of a partially time-expanded graph, for which certain arcs under-estimate real travel times, and therefore allow extra unfeasible consolidations opportunities. However, in our problem storing commodities has a cost. We use the DDD to find the optimal flow in a transportation point of view, and combine it with a storing cost injection procedure, to enrich the partially-time expanded graph. The final solution is an upper bound we compared with the results obtained with Gurobi on the full graph. The comparison reveals our method efficiency, increasing with the instances size.

References

Insular Vehicle Routing Problems

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1 Introduction

This paper introduces a novel class of Selective Vehicle Routing Problems (SVRP, [1],[2]), named Insular Vehicle Routing Problems (InVRP [3],[4],[5]). A set of islands must be served for collecting (or distributing) freight, such as waste, consumables, and raw materials. The vehicles (ships or barges) start and end their trip in a neighbouring mainland port. Each island contains a set of ports and must be served at least through one port. In addition to the allocation of demand across vehicles and sequencing the order of visits, the problem also calls for the selection of ports to be visited. In this sense, the InVRP shares characteristics with the Generalized Vehicle Routing Problem (GVRP [6],[7]). In contrast to SVRP and GVRP, the InVRP also considers how to transport the freight inside each island between the selected ports and the final consumers. The cost of this inland transport is typically expressed as the difference relative to an ideal service level or capture rate. In this sense, the InVRP is bi-objective in its nature. Different operational strategies and assumptions, among other considerations, define the specific problem to be addressed.

This paper aims to introduce the general InVRP. This includes: i) presenting a basic formulation and extensions according to different real-world applications, features and assumptions, and ii) discuss the relevance of the underlying stakeholder dynamics and dependencies in terms of both problem definition and mathematical formulation.

2 A Bi-Objective Formulation with Maritime and Ground Transportation Costs

The parameters are: \( H \), the set of islands; \( \Omega_i \), the set of ports belonging to each island \( h \); \( N \), the set of ports, including a mainland depot \( i_0 \); and \( MC_{ij} \), the maritime transportation costs from the node \( i \) to the node \( j \). Decision variables are: \( Z_h \), a binary variable that indicates if node \( i \) is selected to be visited; \( Z_i \), the set of all \( Z_i \); \( Y_{ij} \), a binary variable that indicates if the node \( j \) is visited immediately after node \( i \). \( GC_h \) is the total ground transportation costs for carrying freight to node or port \( i \) from inside of its island.

A generic bi-objective formulation can now be presented for the case of a single barge visiting all islands:

\[
\begin{align*}
\text{Min} \quad & \sum_{i,j \in \Omega_i, j > i} MC_{ij} \cdot Y_{ij} + \sum_{h \in H} \sum_{i \in \Omega_i} GC_h \\
\text{s.t.} \quad & \sum_{i \in \Omega_h} Z_h \geq 1 \quad (Z_i = 1) \quad \forall h \in H \\
& \sum_{j \in \Omega_i} Y_{ij} = Z_i \quad \forall i \in N \\
& \sum_{j \in \Omega_i} Y_{ji} = Z_i \quad \forall i \in N \\
& GC_h = GC_h^+ (Z) \quad \forall h \in H, \forall i \in \Omega_i \\
& v_{ij} \geq v_i + 1 - M \cdot (1-Y_{ij}) \quad (v_i = 0) \quad \forall i, j \in N, j \neq i_0 \\
& Z_i, Y_{ij} \in \{0, 1\} \quad \forall i, j \in N
\end{align*}
\]

Eq. (1), the objective function, minimizes the maritime transportation costs (first term) and the ground transportation costs inside all islands (second term), based on a bi-objective perspective.
Eq. (2), (3) and (4) are standard SVRP constraints that relate visit sequencing and port selection decisions. (5) are defined to determine the ground transportation costs associated to each port as a function of port selection decisions \(Z\) and the operation strategy \(S\) considered for collecting (distributing) the freight inside the islands. (6) are the well-known MTZ sub-tour elimination constraints, and (7) the domain constraints for the decision variables.

Different specific problem formulations may arise if different operational strategies inside the island are considered. A variety of extensions arise when additional features are to be considered, including multi-period and dynamic routing, capacity constraints, non-linear transport cost, etc. The first studies in this area ([3],[4],[5]) focus on a household waste collection in the South of Chile. Other applications include fresh food distribution, spare part distribution for offshore windfarms, medicines distribution in rural regions, etc.

3 Stakeholder Dynamics

The InVRP combines decision making at various levels within a stakeholder hierarchy to the extent that any corresponding dynamics drive the problem design. Stakeholders may be grouped into (i) public sector (i.e. governmental decision makers), (ii) private sector (i.e. service and 3PL providers), and (iii) system users (e.g. shops, households).

A short discussion of different possible situations further illustrates the above points. In the collection of waste from a set of islands, it is relevant to model the impact of service level offered to households. A badly designed scheme will often lead to low capture rates, which may reduce the collection costs but increases the environmental and social costs of illegal dumping or burning. In contrast, the InVRP in an offshore windfarm servicing network serves to maximise the efficiency and service reliability of the service provider. In the latter example, the routing costs and time to destination may dominate, while in the former example the port selection strategy may dominate.

Most InVRP formulations will contain both strategic and operational decisions of different particular interest to various groups of stakeholders. Aspects of dominance and fairness between and within stakeholder groups with respect to particular decisions (port selection, visit sequencing/frequency, transport organisation inside islands) may also further determine how best to formulate the details in InVRP models. This may lead to formulations not only with multiple objectives, but multiple stakeholders, which may require the consideration of also game theoretic aspects.

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References

Electric and hybrid vehicles play an increasing role in the road transport networks. Despite their advantages, they have relatively limited cruising range in comparison to traditional diesel/petrol vehicles and require significant battery charging time. Given a particular road network layout, determining appropriate locations and capacities for charging stations is a challenging multi-objective optimisation problem with many constraints. Some of the key objectives are to minimise the length of detours from a desired route necessary for recharging while assuming a reasonably small number of charging stations to serve the whole network (e.g., see [2]). We propose to model the facility location problem for the placement of charging stations as a \(k\)-domination problem on reachability graphs derived from the original road network. This model takes into consideration natural assumptions such as a threshold for the remaining battery charge, and provides some guaranteed minimal choice for travelling to recharge the battery. Experimental evaluation and simulations for the proposed model have been done in the case of real road networks corresponding to the cities of Boston (USA) and Dublin (Ireland).

For simplicity, we consider a road network represented by an undirected simple weighted graph \(G^s\). Given a road network graph \(G^s\), we define a reachability graph \(G^r_t\) as a simple (unweighted) graph with the same set of vertices as \(G^s\) and edges \(uv \in G^r_t\) iff the length of shortest path (distance) between the corresponding vertices \(u\) and \(v\) in \(G^s\) is less than a specified reachability threshold of \(t\) km. Having constructed a road network graph \(G^s\) and a corresponding reachability graph \(G^r_t\), the problem of placing charging stations in the road network becomes a facility location problem, which can be modelled on the graphs \(G^s\) and \(G^r_t\) as follows. Given an integer \(k \geq 1\), a set \(X\) of vertices of a graph \(G^r_t\) is called a \(k\)-dominating set of \(G^r_t\) if every vertex \(v\) not in \(X\) has at least \(k\) neighbours in \(X\). The minimum cardinality of a \(k\)-dominating set of \(G^r_t\) is the \(k\)-domination number \(\gamma_k(G^r_t)\). A \(k\)-dominating set \(X\) in the reachability graph \(G^r_t\) provides a set of locations for charging stations in \(G^s\) such that, from any given point in \(G^s\), a driver has at least \(k\) different choices to reach a charging station when the remaining battery power is enough for \(t\) kilometres.

We compute the reachability graphs \(G^r_t\) by performing a modification of the breadth-first search from each vertex \(v\) in \(G^s\), i.e. a modification of Dijkstra’s algorithm, using a binary heap based priority queue. We use heuristics to find \(k\)-dominating sets of reasonably small size in \(G^r_t\). In particular, we use a randomized algorithm inspired by an algorithm from [3]. The algorithm uses as an input a reachability graph \(G^r_t\) and a positive integer \(k\), and returns a (minimal by inclusion) \(k\)-dominating set \(X\) in \(G^r_t\). Our implementation is enhanced with several heuristics and run several times to obtain smaller size \(k\)-dominating sets in \(G^r_t\). We use a simple greedy heuristic to find a \(k\)-dominating set in \(G^r_t\) to use as a benchmark.

We have tested our model and algorithms in the case of two road network graphs corresponding to the cities of Boston and Dublin. The two road networks have been obtained from OpenStreetMap [1]. The graph \(G^s\) corresponding to Boston consists of 21,542 vertices and 31,112
edges. It is contained within a rectangular region of width 15.5km and height 12.1km. The graph $G$ corresponding to Dublin consists of 55,162 vertices and 64,437 edges. It is contained within a rectangular region of width 29.5km and height 24.6km. For these sizes of road networks, we have assumed that $t = 3.0$km is an appropriate reachability threshold. Some of the computational results and statistics are presented in the tables and figure below.

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Boston</th>
<th>Dublin</th>
</tr>
</thead>
<tbody>
<tr>
<td>$k = 1$</td>
<td>Greedy</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>Randomized</td>
<td>31</td>
</tr>
<tr>
<td>$k = 2$</td>
<td>Greedy</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>Randomized</td>
<td>56</td>
</tr>
<tr>
<td>$k = 4$</td>
<td>Greedy</td>
<td>122</td>
</tr>
<tr>
<td></td>
<td>Randomized</td>
<td>115</td>
</tr>
</tbody>
</table>

Table 1: Cardinalities of the $k$-dominating sets computed by using the greedy and randomized approaches for the road networks of Boston and Dublin and different values of $k$.

![Figure 1](image1.png)

Figure 1: The 2-dominating sets computed for the city of Boston: (a) 64 vertices by the greedy algorithm and (b) 56 vertices by the randomized algorithm.

<table>
<thead>
<tr>
<th>Network</th>
<th>Boston Mean</th>
<th>Std</th>
<th>Min</th>
<th>Dublin Mean</th>
<th>Std</th>
<th>Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 km</td>
<td>0.5</td>
<td>0.7</td>
<td>0</td>
<td>0.5</td>
<td>0.7</td>
<td>0</td>
</tr>
<tr>
<td>2 km</td>
<td>1.9</td>
<td>1.1</td>
<td>0</td>
<td>2.0</td>
<td>1.1</td>
<td>0</td>
</tr>
<tr>
<td>3 km</td>
<td>4.3</td>
<td>1.4</td>
<td>2</td>
<td>4.6</td>
<td>1.5</td>
<td>2</td>
</tr>
<tr>
<td>4 km</td>
<td>7.3</td>
<td>1.9</td>
<td>2</td>
<td>8.5</td>
<td>2.3</td>
<td>2</td>
</tr>
<tr>
<td>5 km</td>
<td>10.9</td>
<td>2.6</td>
<td>2</td>
<td>13.7</td>
<td>3.1</td>
<td>2</td>
</tr>
<tr>
<td>6 km</td>
<td>14.9</td>
<td>3.7</td>
<td>2</td>
<td>20.0</td>
<td>4.2</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 2: Three statistics for the number of charging stations reachable from a point on the road networks of Boston and Dublin computed as a function of distance (2-dominating sets).

References


Roll-on/roll-off (RoRo) vessels are those that transport wheeled cargo, such as cars, trucks, and freight on trailer, which rolls on and off a deck of its transportation carrier. RoRo vessels operate over predetermined route consisting of ports where cargo is loaded and unloaded. For efficient RoRo handling and maritime safety, there are required stowage planning, relocation planning, ship stability validation, etc. Compared to container vessel operations, however, the level of computerization and automation of planning activity is relatively low. For example, it is common to plan stowage by assigning a subset of cargo to a certain area of a deck without specifying exact locations. In this case, the precise position is decided by field operators at the time of rolling on. In addition, most research on RoRo operations focuses on ship stability and there are few, practical studies on stowage and relocation planning. This study proposes a methodology that supports and streamlines stowage and relocation planning process for planners.

We take an approach of dividing RoRo stowage planning into subproblems. Each subproblem considers disjoint part of a deck for placing a subset of cargo, which is specified by planners during stowage planning process. The subproblem is modeled as a two-dimensional packing problem with various size of objects (cargo) into an irregular-shaped container (partial area of a deck). We take into account vessel structure (e.g., pillars and ramps) the height of decks, and the safety distance among cargo. The stowage plan is completed progressively by handling the packing problems subsequently, which altogether encompass the entire deck area and the all the cargo to be loaded.

For example, Fig. 1 shows a 2D packing problem for stowage planning. In the figure, shaded area B is the current target area of the packing problem, with the given cargo plan which is the results of the previous planning for partial area A and C. It can be seen that the shape of B is irregular because of pillars, hull shape, and pre-planned cargo.

The stowage plan is evaluated by the deck utilization rate and the roll-on/off efficiency. The deck utilization rate is calculated with the sum of placed cargo size including safety area and the entire deck area available. The efficiency is estimated by the expected roll-on/off processing time. For the processing time estimation, we identify the sequence of handling cargo and determine roll-on/off path by regarding vessel structure and other cargo. We approximate the path length by Manhattan distance and assume that the travel time is proportional to the path length.
The relocation of cargo can be carried out to cope with change in transportation schedule and/or to improve roll-on/off efficiency. Usually it is done while a vessel is out at sea in between ports. The relocation plan is constructed in a similar way to the stowage planning.
Location and Districting of Urban Distributed Service Networks on Street Graphs

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This paper deals with problems of long-range planning that appear in urban distributed service networks. It focuses on the location of stationary service units and the districting-zoning of the network. These are hard to make decisions since they should consider variegated socio-economic and geographical factors, while once such decisions are finalized, it is very difficult to modify them. This paper proposes a mathematical programming based heuristic method to solve large-scale location problems, and a multi-objective local search algorithm to solve districting problems. Various key insights and new performance indicators are presented, while both frameworks are motivated from real life applications and they are capable of solving large scale problems.
Fleet Management: The Case of a Transport Company

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\textsuperscript{a} University of Aveiro

Keywords: Integrated Fleet Management; Telematics; Route Scheduling; Road Freight Transportation

Abstract: In the transport sector, there is a gap that arises in managing fleets with vehicles of different brands, making it ineffective to choose the use of telematics systems that each brand offers. This article presents a solution based on a system that uses a single service aggregating all fleet vehicles, irrespective of brand, and allowing their control at any time. Thus, it results in improved efficiency on the routes based on greater consistency of data as similar driving data are obtained for all vehicles. This article uses a case study that shows it is possible to reduce travelling costs, allowing the generation of greater quality services and hence ensuring customer satisfaction.

1. Introduction

According to Qiu et al. (2017) road freight transportation has become an integral element of the globalized world: more cargo is shipped on roads than rail, water and air shipment combined. It is in this sense that fleet management, continuous improvement and route planning, among other aspects, arise as tools to assist road freight transportation companies in achieving excellence. The new currency of the world economy is information and overall it is expected that the right information at the right time can serve as an aid in decision making and service provision (Duri et al., 2004). In the case of freight carriers, there is a special interest in planning and control of the fleet, which is not always easy, especially when the fleet consists of various vehicle brands. In order to improve this process there is a need to avoid the use of unnecessary and overly long routes (Drexl, 2012) as well as to manage the fleet in an integrated way, using real data. In general, vehicle routing problem literature adopts a highly abstract and unrealistically model of distances, travel times, travel costs and service times (Hoff et al., 2010). In real-life road-based transportation there is a concrete road network that needs to be considered regarding these calculations. Nonetheless, Bräysy and Hasle (2014) consider that it is clear that the quality and cover of both static and dynamic information from Geographic Information Systems and transportation telematics systems are improving rapidly. This study focuses on the context of small- and medium-sized enterprises (SMEs) due to the proximity of the research objective to business reality and the desirability of the contribution for the entity. Specifically, it analyses a transport company involved in fleet management. The company studied presents itself as an investor in the development of software capable of ensuring control and fleet management from the same portal, without differentiating between vehicle brand and type. This article relates to the study of routes for a national freight company and is based on information collected through the fleet management system. The service that allows data transfer is known as telematics and is one of the key points in this study, allowing the effective monitoring of fleets 24 hours a day. Specifically, we intend to choose the best route through the analysis of data collected from the TRACKit program (http://www.trackit.pt/pt/), the peculiarity of which is that it allows comparison between vehicles of different brands. The main objective of this work is thus to present the scope and methodology employed in order to obtain the achievement of better decision making regarding the routes management of the fleet of vehicles of a third-party logistics provider.

2. Methodology

The research developed here was based mainly on qualitative data, focusing on support for greener driving. Some fleet vehicles were followed through the TRACKit system to identify a more economical route than the Bordeaux-Nantes line. The research was developed with the support of the company. The literature review was initially carried out on fleet management and then widened to include telematics, the key point of the investigation. The research aimed to identify the best vehicle route for loads of about 20 tonnes. The study was based on weight, altimetry, speed and fuel consumption and analysed the Bordeaux-Nantes section. Case study methodology was used as the research strategy, characterized by Simons (2000) as “an in-depth exploration from multiple perspectives of the complexity and uniqueness of a particular project, policy, institution, program or system in a ‘real life’”. In addition to this, according to Yin (2014) “doing case study research would be the preferred method in situations when (1) the main research questions are ‘how’ or ‘why’ questions; (2) the researcher has little or no control over behavioural events; and (3) the focus of study is a contemporary phenomenon”. Information gathering was undertaken based on individual semi-structured interviews with the company trainer and the administrators, documentary sources and online databases.

3. Conclusion

Southampton, UK, Oct 18-20, 2017
Data transfer through telematics is a key point for carriers, as they may at any time obtain access to data on their drivers’ behaviour, vehicles and goods. Obtaining these data makes it possible to correct the drivers’ bad habits, optimizing the vehicles’ performance. Through the corrections made, not only can maintenance costs be reduced, but also the fuel consumption can be improved and the quality of the service increased. To achieve efficiency in this sector, it is necessary to adopt innovative systems and fleet management services provide fleet managers with greater ability to control activities and more security in planning. Despite the gains arising from the use of each of the systems that brands offer, for a company with a number of vehicles of different brands, such as that in this study, it becomes impractical to monitor cars by brand and investment in software capable of monitoring all the vehicles in the fleet is preferable. Among the several advantages of the TRACKIT system, we emphasize the cost savings comparison among alternative routes and vehicles, through an illustrative example considering four alternative routes between Gironde (Ambarès-et-Lagrave) and Loire-Atlantique. The analysis performed in this study showed that there are several benefits, amongst which the cost benefits should be emphasized, from using an integrated fleet management system to deal with the routes optimization problem, faced by a road freight carrier. In doing so, the choice of the best combination between routes and vehicles becomes easier and more precise because all the data is fed from the same portal and the same considerations are taken into account.

References
Charging and routing strategies for electric vehicle scheduling considering flexible energy pricing patterns

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Keywords: Electric vehicle charging strategies, Flexible energy pricing, Electric vehicle scheduling

1 Introduction and Related Work

The road transport sector contributes about 21% to global CO₂ emissions, and is the second largest producer of emissions next to the electricity and heat production sector [4]. One way to reduce these emissions is through battery electric vehicles (BEV). Studies show the distribution of BEVs is expected to increase both in the commercial and non-commercial sector [2, 3]. In order to reduce emissions BEVs need to be intelligently integrated into the power grid. The coordination of charging times (smart-charging) for non-commercial vehicles is a new complicated problem that has been the center of many studies [1]. The contribution of the proposed model is to introduce energy efficient charging through the use of valley filling and time-of-use (TOU) tariffs to commercial electric vehicle literature. To do so the model builds on the studies published in regard to the optimal refueling of a internal combustion engine vehicles [5].

2 Problem formulation

The aim of this study is to generate a cost optimal charging schedule for a given routing solution. To generate this schedule a linear programming model was developed and solved using a commercial solver. The model minimizes the costs related to vehicle charging and the wage of the driver. The charging costs are dependent on energy prices that vary in 15-min intervals according to market prices (EPEX Spot continuous). Real-world driving data was obtained from a company conducting the delivery of perishable goods in the business-to-customer sector. The data also includes clustered delivery tours where several customers within a predefined radius are delivered in one stop.
3 Numerical Results

The model was tested on real-world test instances and we show the results in five different scenarios. The numerical findings demonstrate charging strategies, benefits of adapted delivery behavior and implications on depot charging requirements, as determined by the model and battery sizes. The results show that increasing the radius of the clustered routes creates benefits in regard to the charging behavior of the vehicle, as it charges 6 fewer times on average for the cluster with the maximal radius versus the unclustered data. At the same time charging outside of the depot increases by about 9% of consumed energy. We also consider a scenario where the vehicle can leave as desired (i.e. no constraint on departure time). The flexible starting time allows the vehicle to select a low energy cost corridor for its deliveries which leads to a doubling in charges. This also has an impact on the required battery size of the vehicle, as determined by the maximum state of charge throughout the tour. This means the vehicle battery size can be about 40% smaller in comparison to the case where the complete charge is conducted at the depot. On a pure charge cost consideration these are reduced by a maximum of 21% per day.

4 Discussion

The presented model and the obtained results show that under certain tour configurations charging an electric delivery vehicle throughout the tour is viable and can produce cost savings on numerous levels. It enables the deployment of EV’s with smaller batteries and reduces the charging cost. On a grid perspective this charging approach leads to a more balanced consumption of energy and secondly to a distribution of charging throughout the grid. It was also observed that clustering of customer deliveries and longer service times have a positive impact on the charging behavior.

References

Using Large Neighbourhood Search and Guided Ejection Search for Pickup and Delivery Operations in a Collaborative Logistics Environment

M. Mesgarpour, D. Landa Silva, Y. Qu, W. Laesanklang and T. Curtois

Keywords: VRP; PDP; LSN; Split-loads

This study gives an overview of research work within the COSLE (Collaborative Optimisation in a Shared Logistics Environment) project between the University of Nottingham and Microlise Ltd. This is a collaborative R&D project to develop optimisation technology to enable more efficient collaboration in transportation, particularly real-world operational environments involving pickup and delivery problems. The overall aim of the project is to integrate various optimisation techniques into a framework that facilitates collaboration in a shared freight transport logistics environment with the overall goal of reducing empty mileage. At the centre of the research, there is a combined large neighbourhood search and a guided ejection search for the pickup and delivery problem is also presented. It combines proven successful algorithms to gain the benefits of each method. The computational results show the combined approach is effective with a number of new best known solutions produced on a well-known benchmark data set. This project was co-funded by Innovate UK (the UK’s innovation agency) and Microlise Ltd.
Incorporating Future Requests in the Dynamic Workforce Scheduling and Routing Problem

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Abstract

We consider a dynamic workforce scheduling and routing problem, where service requests arrive continuously and randomly over time, and operational decisions are made in an ongoing fashion. To address this problem, we propose a sampling-based model that incorporates stochastic knowledge about future requests. The proposed model uses a two-stage set-partitioning framework, where the first-stage is concerned with finding a set of feasible technician routes covering known requests, while the second-stage estimates the effect of the same routes with respect to future requests. The performance of the proposed model is evaluated against a deterministic model and a naive greedy heuristic within a simulation framework, and tested on realistic instances generated using probability distributions derived from historical data. The computational results demonstrate that the proposed model can provide significant improvements over approaches not exploiting the stochastic information.

Keywords: workforce scheduling; vehicle routing; stochastic knowledge; future requests