Towards the Implementation of Optimal Train Loading Plan in the Athens-Thessaloniki Freight Services

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ABSTRACT

The main goal of train loading optimization is the proper assignment of loading units onto the wagons, taking under consideration numerous factors like the maximum axle load restrictions, the condition of the railway infrastructure, the operating conditions, safety regulations etc. The typical expression of the problem is usually formulated under one of the two following assumptions: (a) the commodity load is predefined or (b) the number and type of wagons is fixed. The current work describes the steps that were followed and enabled the analysis, optimization and integration of the train loading plan into the information system that supports the new railway service of TRAINOSE for containers transport on the Athens - Thessaloniki line. This new service, named iCS, was launched in December 2013 and ever since operates on a daily basis. The work includes a literature review, a mention of the pragmatic aspects that influence container transport and train loading plan, the presentation of the heuristic which is implemented in the information system of iCS service, a validation process against a mixed integer optimization model and finally concludes with the proposed solution for the iCS wagon loading problem.

KEYWORDS

Mixed Integer Programming, Train Loading Plan, TRAINOSE, Wagon Loading Heuristic

1. INTRODUCTION

An effective train loading plan can positively contribute to the profitability of the railway services, train safety, energy consumption and efficiency of rail terminal operations. The main goal of an optimized train loading plan is the proper allocation of loading units to the wagons so that the utilization of the train is maximized while satisfying a number of restrictions. From a “narrow” point of view the focus for the train loading plan is mainly given on the increase of train utilization to the maximum possible degree and thus restrictions such as the length of the available wagons, the maximum allowed axle load (due to railway infrastructure conditions or safety regulations) must be taken into account. Nonetheless, the maximization of carried volume per journey is not the only field that an efficient train loading plan can have a positive effect. From a “wider” point of view the transport system can be benefited as a whole by applying the same optimization techniques but with the emphasis given on a wider spectrum of aspects such as efficient terminal operations, waiting times, level of provided services, etc. The typical restriction examples, imposed on this kind of optimization processes are related to the available handling equipment, the acceptable average truck waiting time, etc.
In the current work, the algorithm that performs the container train loading plan for TRAINOSE’s intermodal Cargo Shuttle (iCS) is presented and validated. The remainder of the paper includes: the literature review (Section 2) where studies addressing the “narrow” and the “wider” view of train loading problem are presented. Sections 3 and 4 present the pragmatic aspects of a wagon loading process as well as the algorithm/heuristic developed and used by iCS. Next, in Section 5 the process for the evaluation of the above heuristic is analyzed. The last part, Section 6, hosts the conclusions.

2. STATE OF THE ART

An effective train loading plan can lead to significant and multilateral gains by reducing monetary, time and environmental costs and thus a significant number of researches have driven their attention towards this field (Bontekoning, Macharis, & Trip, 2004). Although, the majority of the studies are relevant to sea port container terminals (Ambrosino & Siri, 2014; Stahlbock & Voß, 2007), nevertheless, a number of studies has started emerging for hinterland terminals also.

The problem of train loading is a subcategory of the problem known in the scientific society as “bin packing”. According to this problem, objects of different volumes (containers) must be packed into a finite number of bins (wagons) in a way that minimizes the number of bins used. Solving techniques based on mathematical models using integer linear programming or metaheuristics are the most well-known approaches to tackle this class of problems. Examples of the constraints taken into account are (narrow view) the maximum weight attached onto wagons, the maximum number of containers per wagon, the number of wagons attached to a train and its total weight as well as (wider view) terminal equipment resources, maximum truck waiting time allowed, etc.

One of the first works concerning the narrow view of the problem is the one of Feo & Gonzáles-Velarde, (1995) who treated the problem of assigning trailers to wagons. Their models and solutions were based on the assumption that no more than two trailers can fit on one wagon. Nearly a decade later, Corry & Kozan, (2006) optimized the train load planning with respect to the service and loading time as well as the restrictions imposed by the safety regulations, which determine the weight distribution along the train. Only one type of container and no weight restrictions for the wagons were taken into account. In a subsequent paper Corry & Kozan, (2008) focused on the minimization of the train length and the total train service time. Neither weight restrictions for the wagons nor for the whole train were considered. An integer linear program was developed but due to its complexity, realistic problem instances were tackled by use of heuristics (local search). A recent work on the subject was this of Aggoun, Rhiat, & Grassien, (2011) that incorporated into the problem the aspects of business constraints, like handling of dangerous commodities and incompatibilities between families of containers.

As far as the wider view of the train loading problem is concerned, the optimization process can focus on a wider range of desirable outcomes. For instance, Powell & Carvalho, (1998) aimed to optimize the general problem of circulation of intermodal wagons along the network. Given the specific demands for a number of trains with different transport destinations, the optimal combination of wagons was determined. The same year Bostel & Dejax, (1998) formulated the problem with the emphasis given on the minimization of the distance travelled by the container handling equipment. This was achieved by optimizing the positioning of the incoming and out-coming containers of the terminal. For reasons of simplification only one container type was considered. Bruns & Knust, 2010, tried to simultaneously maximise the train utilization whilst the terminal’s transportation costs were minimized. They proposed three different integer linear programming formulations in which the real weight restrictions related to wagon configurations were also considered. Another interesting fact
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