Some POPMUSIC Applications in Logistics

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Abstract

In this paper we report on recent success stories in solving some logistics problems by means of matheuristics, like the Berth Allocation Problem as it is found in maritime shipping and the operations of container terminals. As an example we propose two POPMUSIC (Partial Optimization Metaheuristic Under Special Intensification Conditions) approaches that incorporate an existing mathematical programming formulation for solving it. POPMUSIC is an efficient metaheuristic that may serve as blueprint for matheuristics approaches once hybridized with mathematical programming. In this regard, the use of exact methods for solving the sub-problems defined in the POPMUSIC template highlight an interoperation between metaheuristics and mathematical programming techniques, which provide a new type of Approach for this problem. Computational experiments reveal excellent results outperforming best approaches known to date.

Keywords: Matheuristic, Popmusic, Metaheuristics, Corridor Method, Logistics

A natural way to solve large optimization problems is to decompose them into independent sub-problems that are solved with an appropriate procedure. However, such approaches may lead to solutions of moderate quality since the sub-problems might have been created in a somewhat arbitrary fashion. Of course, it is not easy to find an appropriate way to decompose a problem *a priori*. The basic idea of POPMUSIC is to locally optimize sub-parts of a solution, *a posteriori*, once a solution to the problem is available. These local optimizations are repeated until a local optimum is found. Therefore, POPMUSIC may be viewed as a local search working with a special, large neighborhood. While POPMUSIC has been acronymed by [10] other metaheuristics may be incorporated into the same framework, too (e.g. [8]). Similarly, in the *variable neighborhood search* (VNS) [4] the neighborhood is altered during the search in such a way that different, e.g. increasingly distant, neighborhoods of a given solution are explored. Such method can be enhanced via *decomposition*, as in the *variable neighborhood decomposition search* (VNDS) (see, e.g., [5]).

For large optimization problems, it is often possible to see the solutions as composed of parts (or chunks [11], cf. the term vocabulary building). Considering the vehicle routing problem, a part may be a tour (or even a customer). Suppose that a solution can be represented as a set of parts. Moreover, some parts are more in relation with some other parts so that a corresponding heuristic measure can be defined between two parts. The central idea of POPMUSIC is to select something that we call *seed part* and a set P of parts that are mostly related with the seed part to form a sub-problem.

Then it is possible to state a local search optimization frame that consists of trying to improve all sub-problems that can be defined, until the solution does not contain a sub-problem that can be improved. In the frame of [10], the set of parts P corresponds precisely to seed parts that have been used to define sub-problems that have been unsuccessfully optimized. Once P contains all the parts of the complete solution, then all sub-problems have been examined without success and the process stops. Basically, the technique is a gradient method starting from a given initial solution and stoping in a local optimum relative to a large neighborhood structure.

POPMUSIC may serve as a general frame encompassing various other approaches like Large Neighbourhood Search, Adaptive Randomized Decomposition etc. An older research which may serve as motivation relates to solving the job shop problem by means of the shifting bottleneck heuristic [1]. The idea of developing heuristics identifying a small/moderate size subset of variables in order to intensify the search in a promising region of the solution space has been used in other contexts. In the knapsack problem family, e.g., [3] propose the idea of selecting a small subset of items (called the core) and solving exactly a restricted problem on that subset. The use of an expanding method to modify the size of the core during the algorithm execution is proposed by [7]. In the same spirit we may consider the *corridor method* (CM) [9]. The basic idea of the CM relies on the use of an exact method over restricted portions of the solution space of a given problem. The concept of a *corridor* is introduced to delimit a portion of the solution space around an incumbent solution. Consequently, the CM defines method-based neighborhoods, in which a neighborhood is build taking into account the method M used to explore it. Kernel Search [2] is also based on the idea of exhaustively exploring promising portions of the solution space.

In this paper we report on some successful matheuristics applications for some logistics problems. As an example consider the Berth Allocation Problem which aims at assigning and scheduling incoming vessels to berthing positions along the quay of a container terminal. This problem is a well-known optimization problem within maritime shipping. We propose two POPMUSIC approaches that incorporate an existing mathematical programming formulation for solving it (see [6]).

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