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The comparison of the metaheuristic algorithms performances on airport gate assignment problem

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Abstract

The airport gate assignment problem (AGAP) is an important research area in air transportation planning and optimization. In this paper we study the airport gate assignment problem where the objectives are to minimize the number of ungated flights and the total walking distances. In order to solve the problem, we proposed a new tabu search (TS) algorithm which uses a probabilistic approach as an aspiration criterion. We compared two metaheuristics, namely, TS, and simulated annealing (SA). A greedy algorithm used as a benchmark. We compared the performances of the algorithms and analyzed at different problem sizes. Experimentations showed that the new proposed metaheuristic algorithm gave promising results.

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Keywords: Gate assignment; Metaheuristics; Tabu search; Simulated annealing

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1. Introduction

Airport management includes very complex issues. One of the important tasks in the airports is to assign flights to available gates. The more efficient gate assignment plan results in lower flight delays, better customer services, and higher utilization rates for the usage of ground facilities. Clearly, this leads lower operating costs. Additionally, passenger satisfaction increases.

The Airport Gate Assignment Problem (AGAP) can be defined as finding feasible flight-to-gate assignments which optimize a performance measure. Mostly, the AGAP minimizes total passenger walking distances. The walking distances considered in airports are: (1) the distance from check-in counters to gates, (2) the distance from gates to baggage claim areas, and (3) the distance from one gate to another one for transfer passengers. Sometimes the number of flights exceeds the number of available gates. In this case, airport planners also aims to minimize the number of ungated flights.

Almost all kind of modelling approaches, i.e. integer, binary or mixed integer, linear or nonlinear models, are applied to AGAP in the studies in literature. Different solution techniques are also proposed to solve the models. Mainly researchers want to find an optimal or at least a good-quality solution in a reasonable time. The solution methods to the AGAP can be classified as either exact or heuristic methods. Exact solution algorithms assure finding optimal solution while heuristic algorithms do not guarantee the optimal solution. However, recent studies mostly focus on heuristics to solve AGAP because of the complexity of the problem.

The airport gate assignment problem has been extensively studied in the literature since the early 1980s. Babic et al. (1984) and Bihr (1990) proposed a 0-1 integer programming model, and solve by Branch and Bound (B&B) algorithm. Mangoubi and Mathaisel (1985) developed a linear relaxation of an integer program formulation and solved the problem by a heuristic algorithm. Bolat (1999, 2000) developed a mathematical model formulation and solved the problem by B&B algorithm and a constructive heuristic algorithm. Yan and Huo (2001) formulated a multiple objective 0-1 integer model and used the column generation and B&B approaches.

Although the AGAP is a NP-hard problem (Ding et al., 2004, 2005; Lim et al., 2005), research efforts in recent years have focused on developing the heuristic and metaheuristic algorithms. The studies which use a problem specific heuristic approach are Bolat and As-Saifan (1996), Haghani and Chen (1998), Yan and Tang (2007), Dorndorf et al. (2008, 2012), and Genç et al. (2012). Finally, mixed integer programming based heuristic algorithm was presented by Yu et al. (2016). There are several studies in literature using metaheuristic approaches to solve the AGAP. Bolat (2001) proposed a genetic algorithm after discussing five different models for gate assignment. Xu and Bailey (2001) and Ding et al. (2004) formulated the gate assignment problem as a quadratic assignment problem and used tabu search metaheuristic. Ding et al. (2005) gave a 0-1 integer linear programming model. Authors firstly used a greedy algorithm to exchange the moves and then they applied simulated annealing and a hybrid approach of simulated annealing and tabu search. Lim et al. (2005) used a time shift algorithm then they applied tabu search and memetic algorithm. Hu and Paolo (2007) provided genetic algorithm for the multi-objective AGAP. Drexl and Nikulin (2008) addressed the problem similar way in Ding et al. (2005) and they used pareto simulated annealing approach. Cheng et al. (2012) compared three metaheuristics; genetic algorithm, tabu search, simulated annealing, and a hybrid approach made of simulated annealing and tabu search. Şeker and Noyan (2012) introduced the uncertainty into problem structure and developed a stochastic programming model with robustness measure. They employed tabu search algorithm to obtain assignments of reasonable quality. Marinelli et al. (2015a) introduced the bee colony optimization to solve the AGAP. A hybridized biogeography-based with bee colony optimization metaheuristic was proposed by Marinelli et al. (2015b) for solving AGAP, too.

Due to nature of the problem, stochastic models are considered as a tool to solve in the literature for AGAP. Cheng (1998) introduced a rule-based simulation method for the activities of aircraft on gates in apron control. Yan et al. (2002) analysed the effects of stochastic flight delays on static gate assignments, and evaluated flexible buffer times and real-time gate assignment rules. Narciso and Piera (2015) proposed a simulation-based experimental approach to evaluate the impact of AGAP policies.

The most recent survey on AGAP is by Dorndorf et al. (2007) and Bouras et al. (2014) where most of the existing literature is reviewed.

Many different objectives have been considered in the literature for AGAP. The most widely used objective is the minimization of the passenger walking distance (Babic et al., 1984; Bihr, 1990; Mangoubi and Mathaisel, 1985; Yan and Huo, 2001; Ding et al., 2004, 2005; Lim et al., 2005; Hu and Paolo, 2007; Yan and Tang, 2007; Drexl and Nikulin, 2008; Cheng et al., 2012; Marinelli et al., 2015a, 2015b). The objectives commonly used in the literature