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Fusion of two metaheuristic approaches to solve the flight gate assignment problem

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Abstract

One of the most important activity in airport operations is the gate scheduling. It is concerned with finding an assignment of flights to terminal and ramp positions (gates), and an assignment of the start and completion times of the processing of a flight at its position. The objectives related to the flight gate assignment problem (FGAP) include the minimization of the number of flights assigned to remote terminals and the minimization of the total walking distance. The main aim of this research is to find a methodology to solve the FGAP. In this paper, we propose a hybrid approach called Biogeography-based Bee Colony Optimization (B-BCO). This approach is obtained fusing two metaheuristics: biogeography-based (BBO) and bee colony optimization (BCO) algorithms. The proposed B-BCO model integrates the BBO migration operator into to bee's search behaviour. Results highlight better performances of the proposed approach in solving FGAP when compared to BCO.

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Keywords: Flight gate assignment; Bee Colony Optimization; Biogeography Based Optimization; Multicriteria analysis

1. Introduction

In recent decades, there has been a strong increase in air traffic, up to hundreds of daily flights in large international airports. Therefore, airport operations have become more complex. The flight gate assignment problem is encountered by gate managers at an airport on a periodic basis. This assignment should be made so as to balance carrier efficiency and passenger comfort, while providing buffers for unexpected events that cause assignment

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disruptions. The gate assignment problem can be seen as a scheduling problem. Gate scheduling defines the assignment of flights to terminals or ramps, called gates. It is a key activity for airport operations. Flight schedule defines the period required to carry out operations to process a flight and the gate assigned to that flight.

The most important objective of flight gate assignment problem (FGAP) is to minimize the distance walked by passengers and the distance between connecting flights.

In an airport three main distances can be considered:

- the distance between the gate and the check-in area;
- the distance from gate to gate for transfer passengers;
- the distance between the baggage claim area (check-out) and the arrival gate.

The most important information for gate scheduling are referred to the arrival and departure time, the type of aircraft, and connections between pairs of successive flights served by the same aircraft. In the following sections, we describe the methodology used for the model of the Biogeography-based Bee Colony Optimization (B-BCO), obtained by the fusion of the Biogeography-Based optimization (BBO) and Bee Colony Optimization (BCO). We have considered the case of the international airport of Milan-Malpensa to test the proposed method. Finally, in Section 6, some concluding remarks are given.

2. Literature review

In literature, there are numerous mathematical models for flights assignment to gates. A detailed survey is given by Dorndorf et al. (2007). Exact algorithms are rarely used for allocation of flights to a gate. Babic et al. (1984) formulated the gate assignment problem as a linear problem. A branch-and-bound algorithm is used to minimize the walking distance and to find the optimal solution, but transfer passengers are not considered.

Most papers present heuristic approaches. Xu and Bailey (2001) define a tabu search algorithm for an airport with the aim of minimizing the passenger walking distances, considering connecting flights. A two-stage algorithm is proposed to solve the problem. It uses both a greedy strategy to minimize the number of un-gated flights, and an improved tabu search heuristic to minimize the total connection time. Drexl and Nikulin (2008) consider multiple objectives such as minimizing the number of ungated flights and the total walking distances, as well as maximization of the total gate assignment preference score.

Modeling the flight-gate assignment problem as a clique-partitioning problem can be found in Dorndorf et al. (2008). They solve the problem by using an ejection chain heuristics. Other models try to improve the performance of static gate assignment by taking into account stochastic flight delays. Hassounah and Steuart (1993) show that planned buffer times could improve schedule punctuality. Yan and Chang (1998) and Yan and Huo (2001) use in their static gate assignment problems a fixed buffer time between two contiguous flights assigned to the same gate, in order to hold stochastic flight delays. Yan and Chang (1998) formulated the airport gate assignment as a multi-commodity network flow problem. Yan and Huo (2001) formulate a dual objective 0–1 integer programming model for the aircraft position allocation. The first objective is minimizing the passenger walking time, while the second objective aims at minimizing passenger waiting time. Yan et al. (2002) propose a simulation framework, that is not only able to analyze the effects of stochastic flight delays on static gate assignments, but can also evaluate flexible buffer times and real-time gate assignment rules.

Some authors take into account the dynamic character of the FGAP. A delayed departure may delay the arrival of another aircraft scheduled to the same gate, or require the flight to be reassigned. Bolat (2000) proposes mathematical models and heuristic procedures to provide solutions with a minimum dispersion of idle time periods for the FGAP.

Other authors focus on the design of so-called rule-based expert systems. An expert system uses production rules to produce assignments, but at a cost of large number of factors to be taken into account. The most crucial task is to identify all the rules, put in order by importance and list them appropriately. Hamzwawi (1986) introduces a rule-based system for simulating the assignment of gates to flights and for evaluating the effects of particular rules on gate utilization. Gosling (1990) describes an expert system for gate assignment that has been applied to a major hub of Denver Stapleton airport. Srihari and Muthukrishnan (1991) use a similar approach to solving the FGAP, applying additionally the sensitivity analysis. Cheng (1997) describes the integration of mathematical programming techniques into a knowledge-based gate assignment system to provide partial parallel assignments with multiple