The Crew Pairing Problem for the Tunisian Airline Company based on Hybrid Approach

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Inroduction:

All airline company are looking for minimizing costs and providing a good quality of service. For this reasons, they seek to secure all their flights with affording a good planning to their crew member.

Airline Crew Scheduling Problem (CSP) is one of the most important problems in the area of air transportation. It consists of preparing a planning to assign a group of crew members to a set of flights. The CSP is used to be divided into two main processes [8]: The crew pairing problems (CPP) and crew rostering problems (CRP).

Crew pairing and rostering are considered as two-stage problems, where the output of CPP is the input of CRP. In this study, we focus on the first stage and particularly on the crew pairing generation. Generated crew pairing are then assigned to all available crew.

A crew pairing is solved by giving a sequence of flight legs as input for an undefined crew member, starting and ending at the same crew base, within the same fleet. Our main objective is to generate a set of all legal crew pairings that cover all the flight legs within the lowest-cost, under some legal duty period.

Three main variants for the CPP are proposed: a daily time horizon, a weekly time horizon and a monthly time horizon. Many researchers have focused on monthly time horizon, because it is the most realistic one. This CPP variant takes into account the vacation periods and the variations in the flight schedules.

Based on the previous works, the CPP methodology has been divided into two: the first stage, focus on the generation of all legal pairings, whereas the second stage is dedicated to select the optimum pairings that cover all flight legs with a minimum cost.

In this study, we propose a new problem formulation for the CPP applied to a real case study for Tunisian airline Company. The first phase for generating all legal pairing is formulated as a shortest path problem (SPP) on a structured network. The SPP takes as input a set of flight legs under some constraints called duties periods. The latter are set by the Tunisian Ministry of Transport and Communication in 2017.Then, the optimization phase is modelled as a set covering problem (SCP).

The literature reveals that many researchers have proposed various methodologies to solve the CPP. [2][5][6] Presented several surveys on CPP. As the CSP is proven to be an NP-hard constrained problem [8]; the two main approaches used to solve this problem are: row approach proposed by [9][1][4] and column generation approach (or network approach) (CG) which presents the widely used technique to generate legal pairings for large-scale linear programming problems.

[3] Compare three hybrid approaches to solve the CPP where the CG approach is considered as the third solution and solved by the SPP under some duty constraint. Duty presents the time period which contains one or more flight legs, and the sum of all flight time and connection time that crew members cannot exceed it. In most proposed CPP formulations, duty time has been considered as fixed constraints.

For new CPP formulation, we will consider the duty time constraint as not fixed, which depends on the departure time of the flight and the lending's number for the monthly time horizon variant.

Resolution approach:

For our proposed CPP formulation, two solution approaches are proposed for the two stages mentioned before (1) the crew pairing generation and (2) the pairing optimization.

In our real case study, we used exact method to solve the CPP for the small scale problems. However, a hybrid approach is proposed, for large instances, wich combine the CG and zero-one integer programming model of the SCP.

The main idea for the CG is to generate the maximum number of pairing with minimum of cost. The first step, in this case is to construct the flight network with possible connection. Where, each flight network is composed by nodes and arcs, nodes present the arrival and departure of each flight leg and the arcs present the connection time between flights. Added to that, each crew has a home base that should be mentioned with two additional nodes.

In the second step, we solve the SPP to generate a set of all legal pairings. Finally, all generated pairing will be solved as a zero-one integer programming of the SCP.

Finding:

In this section, we present a brief view on the findings concerning the studies that will be conducted. We proposed a Hybrid CG approach to solve the CPP for the Tunisian airline company. So, we will provide results of real-world examples and we will use the optimization software CPLEX as a solver for the SPP and the SCP.

Experimental results, for various sizes problem, show a high quality of the generated efficient solution with respect of the problem settings.

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