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DYNAMIC PROGRAMMING OF FLIGHTS BASED ON STOCHASTIC DEMANDS

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ABSTRACT

The definition of the flights schedule is one of the major planning activities that are carried out in an airline. The result of the definition of this schedule has implications that transcend the operational sphere and becomes a determining factor to improve competitiveness in the sector of air transportation. The strategic nature of this activity implies that often is carried out so early, in a period where the forecast for the passenger demand is quite diffuse. This lead often to flight with an aircraft with empty seats, or to assign too many passengers to an specific flight. In this paper we present the DACRA algorithm. DACRA enables a continuous adaptation of the flights schedule to a modifications with respect to the forecasted passenger demand for a specific date. Also it assures that new generated solutions are operationally feasible.

1 INTRODUCTION

The schedule of flights, flight plan (FP), is the starting point for all planning activities that are carried out in an airline (Bazargan 2010). The strategic nature of this activity justifies the fact that will be defined in advance to the definition of the rest of the other planning activities. Generally this plan is defined a year before the departure of a flight (Warburg et al. 2008). In this advance, make decisions about which markets to serve, which schedules serve them and what capacity must be offered, is done with little forecasts sharp and with high uncertain about the demand of passengers for each one of the company routes. On (Berge and Hopperstad 1993) is quantified the variability of the demand in a typical deviation which varies between 20% and 50% of the average of passengers envisaged for each flight. The set of activities that make up the planning process of the FP for an airline, represents the central pillar of his strategy because FP fix the markets to go, how often and at what hours. All this must be achieved following the operational and staff restrictions. To do this, the airline carry out the following activities (i) design of the flight program; (ii) fleet allocation; (iii) crew schedule; (iv) maintenance planning and flights registration; (v) markets; (vi) previsions and (vii) costs.

2 DACRA ALGORITHM

DACRA algorithm (Dynamic Airline Capacity Reassignment) has been designed as a meta-heuristic that combines small changes over the departure schedules (re-timing) and reassign fleets (re-fleeting), obtaining pseudo-optimal solutions that allows to maximize the value of the goal function (maximize the profit). The algorithm is based on (Jiang 2006) but with the aim to find, not the optimal solution but a good solution in a small computation time. The existence of an optimal solution is based on the existence of a set of limitations that constrains the exponential grow of the solutions tree. For the DACRA algorithm it is needed the FP and the passengers expected forecast. Also it is needed to obtain the operational and fixed costs for each route and fleet type. Three main elements must be defined, FP, the Fleets, and the Flights. The mathematical formulation of the objective function is shown in the next equation.

$$max \sum_{m \in M \; r \in R(m)} x_{mr} fare_m^F - \sum_{l \in L(M)} \sum_{\pi \epsilon \Pi(M)} C_{l\pi} - \sum_{l \in L(M)} \sum_{\pi \epsilon \Pi(M)} Z_{l\pi} - \sum_{l \in L(M)} n_l Y \quad (1)$$

Where:

- M: is the set opf markets
- R(m): is the set of itineraries that serves a market m $\in$M.
- X_{mr}: Quantity of passengers assigned to an itinerary r $\in$ R of the market m.
- $fare_m^F$: Average fare for the market m.
- L(M) set of flight (legs) that gives service to a set of markets M.
- Π(M): Set of gleet types that serves a set of markets M.
- $c_{l\pi}$: Operative cost (variable) derived of assigning a plane of type π to a flight l.
- $Z_{l\pi}$: Fixed cost derived of assigning a plane π to the flight l.
- n_l: 0 if flight l is a direct flight. Λ u.m if the flight l is serving to the market with a connection.
- Y: cost related to the handling needed on connecting flights.

In order to maximize the value of this function, DACRA algorithm will improve the adjustment between the passengers demand forecasting for each market and the total capacity available (number of seats) in that market. That is to say, try to minimize the deviations between the available places and demand forecast. DACRA algorithm will execute small chances over the input FP. This small changes are retiming, changes on the flights schedules, and refleeting, changes on the fleets assigned to each flight.

3 RESULTS

To perform the experimental design we are using the experiments developed by (Jiang 2006). We perform a total of 75000 iterations with the algorithm for each one of 15 initial instances generated by the random parameters. DRACA achieves an increase of the net operating profit (on average) of 1.83% for each day of operation; in this particular case, this increase translates into 19.617,93€ additional net profit per day. 95% of this improvement is attributed to an increase in the volume of daily income which is, on average, 0.3% or 18.726 € 20 per day; the remaining 5% improvement corresponds to a reduction of operating costs which is, on average, of 0.02% or a cost savings equivalent to 891,73€. Bearing in mind that these are daily results, it is easy to project a potential increase of the annual net profits of one airline that operates with a low-cost model to quantify in a total of 7.160.545,67€ by year.

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