No More Surprises: Stand Assignment Algorithm with Likelihood of Turnaround Time Deviation

Generating delay-aware stand assignment, optimized for the desired management perspectives

Bagamanova, Margarita; Mujica Mota, Miguel

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Generating delay-aware stand assignment, optimized for the desired management perspectives

Margarita Bagamanova
Telecommunications and Systems Engineering
Universidad Autonoma de Barcelona
Barcelona, Spain
margarita.bagamanova@uab.cat

Miguel Mujica Mota
Aviation Academy
Amsterdam University of Applied Sciences
Amsterdam, the Netherlands
m.mujica.mota@hva.nl

***Abstract*—Airport management is frequently faced with a problem of assigning flights to available stands and parking positions in the most economical way that would comply with airline policies and suffer minimum changes due to any operational disruptions. This work presents a novel approach to the most common airport problem – efficient stand assignment. The described algorithm combines benefits of data-mining and metaheuristic approaches and generates qualitative solutions, aware of delay trends and airport performance perturbations. The presented work provides promising solutions from the starting moments of computation, in addition, it delivers to the airport stakeholders delay-aware stand assignment, and facilitates the estimation of risk and consequences of any operational disruptions on the slot adherence**

Keywords- risk; airports; airspace;congestion;stand assignment; turn-round time; decision support

I. INTRODUCTION

In terms of rapid growth of air transport traffic and propagation of reactionary flight delays, it is essential to perform efficient management of airport facilities, maintaining costs as low as possible and keeping airport's KPIs on the required level. One of the most important problems that airport and airline managers have to be concerned about is efficiency of stand scheduling. Boost of air traffic and congestion of airport capacity have significantly increased the service complexity, which is further complicated by changes in the flight schedule on the day of operation. Poor terminal performance caused by inefficient stand scheduling can lead to decreasing of passenger service quality and increasing of turn-round time that can create a propagation of a delay to the successive flights and connected airports. Thus, it is necessary to make an optimal and effective use of terminal facilities, such as stands, to increase airport performance and to mitigate the propagation of negative effects through the air transportation network.

II. PROBLEM STATEMENT

A. Stand Assignment

The problem of stand allocation or stand assignment (further referred as SAP), as well as the similar problem of gate allocation, has been widely studied over the decades and numerous approaches have been applied to different sets of objectives, constraints and outcomes. SAP is a scheduling problem, which is NP-hard due to real-life quantity of constraints and decision variables. According to the methodology used, the solving approaches can be divided into three categories: exact algorithms, heuristic algorithms and combined algorithms. While the first ones aim to find the best solution from diverse perspectives, the rest are designed to determine a qualitative near-optimal solution in a reasonable computational time [1]. Due to the complex nature of the problem, exact algorithms (e.g. branch-and-bound algorithm) have difficulty in providing optimal solutions within reasonable computational times for large-scale stand assignment problems. Therefore, recent studies mainly focus on developing heuristic algorithms, which do not guarantee optimal solutions, but may provide near-optimal solutions in reasonable computational times. However, if a heuristic algorithm fails to find the solution, it is not possible to determine whenever it is due to the absence of any solution or due to the inability of an algorithm to move from local search region [2]. On the contrary, this work shifts the scope from the generation of better solutions to the assessment of the generated solutions not only from the objective function's value perspective, but also from the perspective of the risk of inconsistency of the generated schedule to the reality of operations.

Being a structural component of a very complex and tightly interconnected system, airports suffer from various types of uncertainties. This unpredictability is a natural part of the air transportation network, as many activities can suffer changes in the very last moment, affected by the weather conditions, governmental regulations, air traffic control and etc.

One of the main consequences of such uncertainty are flight delays and early arrivals. Some flights suffer from delay, originated in previous legs and propagating through the network as reactionary delays. Other flights can be coming to their destinations earlier than expected. Both of these deviations create additional load to the decision-making process. This work

implies instead of predicting exact values of flight delays, estimate the probabilities of having a certain delay level for each flight and use this information for estimating the quality of the stand assignment schedule.

III. Methodology

We propose a concept of a stand assignment algorithm that deals both with environmental uncertainties and with optimization of facilities' usage. The algorithm consists of two modules. First module estimates probabilities of delays and their level based on the historical data of previous operational periods. The second module generates the assignment schedule, based on the desired technical and operational restrictions for a target flight schedule, and optimizes it with a genetic algorithm component. To calculate the stand occupancy time for each flight, we estimate in-block and off block times based on the target flight schedule and the delay probability, obtained in the first module.

To generate a stand assignment schedule for a specific operational day, the following data is used:

- Target flight schedule for assignment.
- Existing parking facilities and their technical and operational restrictions (compatible with specific aircraft types, individual use by certain airlines or for certain origins/destinations).
- Availability of stands.

Finally, assignment policy specific data, such as taxi time, walking distances for transfer passengers, etc., are added to the data set as well.

A. Algorithm Architecture

As it has been mentioned in the previous section, the algorithm consists of two modules: one - to estimate the probabilities of delay, and one - to generate a stand assignment schedule, optimized for specific management goal (minimizing transfer passengers walking distances, minimizing taxi time, etc.).

The first module is directly connected to a performance database, which allows re-estimating the delay probabilities in real time, considering also recently available information, e.g. about flight regulations and weather conditions. In this module, the historical delay values are analyzed for different combinations of factors (e.g. airline, aircraft type, operational hour, and weather conditions) and corresponding Bayesian distributional regression models are built. These models together with the corresponding parameters are then passed on to the second module.

In the second module, the target flight schedule is recalculated, according to the regression models obtained in the previous step, and the estimated delay values are added to the block occupancy times. After that, this recalculated flight schedule is passed to a metaheuristic solution search algorithm, which looks for a better stand assignment for the flights, optimizing the user-specified objective function or the weighted combination of them.

The number of iterations, total running time and objective function value can limit the calculation time, according to the user needs. Therefore, the solution quality improvement is only restricted by the user estimations.

B. Algorithm Output

On the exit of the second module component, metaheuristic search algorithm, the stand assignment schedule is obtained. Within the obtained schedule, for every flight, assigned to the stand, the deviation risk value is displayed. This risk value indicates that although the flight is assigned to the specific stand, there is a probability of N percent that this flight will suffer delays and affect the rest of the assignment schedule. By displaying such information, we intend to provide the airport managers with an insight to the most critical points in the schedule and facilitate the decision-making process with a quantitative estimation of possible operational scenarios. In such a way, it is possible to measure the impact of any air traffic regulations on the slot adherence and generate various stand assignment schedules for different performance scenarios with different levels of risk.

IV. Conclusions

In this work, we present a conceptual solution to the most common airport problem – efficient stand assignment. The presented algorithm combines benefits of data-mining tools and metaheuristic approaches and generates qualitative solutions, conscious to historical delay trends and performance drops. This two-module algorithm generates promising solutions from the first iterations, it provides airport stakeholders with an approach for delay-aware stand assignment and facilitates the estimation of impact of operational disruptions on the slot adherence.

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