Tail Assignment in Practice

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Abstract. Tail Assignment is the problem of assigning specific aircraft to flights, producing a fully operational, robust schedule which fulfills operational constraints, while minimizing a cost function. The costs are usually related to robustness and quality of the solution, e.g. to penalize short times between flights and reward "crew-friendly" connections. Carmen Systems' Tail Assignment system utilizes a combination of optimization methods and constraint programming to solve this problem. An interesting aspect of the system is that it can solve several fleet types at once, moving towards an integration of the traditional two-step approach of first solving the Fleet Assignment problem and then Tail Assignment. The article intends to explain some of the methods used.

1 Introduction

Resource optimization is becoming increasingly more important for airlines. Much work has been done in the crew planning area, e.g. Crew Pairing, and Crew Rostering, see [1] for references. This article will focus on a less explored problem in aircraft planning, the Tail Assignment problem.

A typical planning process for an airline begins with the construction of the timetable. The market is analyzed in order to find attractive destinations and times. After the timetable is done, it is decided which fleet should operate each flight, this process is called Fleet Assignment. In Fleet Assignment, among other things, the expected number of passengers for a specific flight is taken into consideration. A fleet with enough seats to accommodate all passengers has to be chosen, but the number of empty seats should be minimized. After Fleet Assignment is done, the crew can be planned, since the type of the aircraft decides what kind of crew is needed. This is done in two steps, Crew Pairing and Crew Rostering. Roughly, in Crew Pairing anonymous building blocks, called *pairings*, are created. Crew Rostering then creates a schedule, called *roster*, for each crew member. Tail Assignment, the process of creating a schedule for each aircraft, also called *route*, can be done at any stage after the Fleet Assignment is done, but is in many cases done late in the planning process. Tail Assignment is similar to the Crew Rostering step, in the aspect that schedules are created for specific individuals.

2 Tail Assignment

This section describes the Tail Assignment problem (TAS). For a thorough description and references, see [1]. TAS is the problem of constructing routes for specific aircraft, which are identified by a number on the tail fin, hence the name of the problem. In other processes of airline scheduling, as Crew Pairing and Fleet Assignment, the objective function is clearly associated with money. In TAS the costs are rather defined in terms of robustness and quality of the solution. It is for example desirable to avoid very short or medium time connections between flights. The short connections make the schedule sensitive to disruptions, while the medium time connections make the aircraft stand on the ground waiting for the next flight, but unable to do any flights in between. Longer connections makes it possible to use the aircraft as a *standby*, i.e. it can perform extra activities in the event of disruptions. If Tail Assignment can interchange information with Crew Pairing, it is possible to avoid unnecessary aircraft changes for the crew, making the schedule less sensitive for disruptions. An example where a where a good TAS solution is clearly related to direct savings, is when certain aircraft are leased, thus making them more expensive to use. It is possible to make flights more expensive for these aircraft, hence the optimizer will try to avoid them. The cost for leasing an aircraft is in the order of thousands of dollars per flight hour.

The most important operational constraints are maintenance constraints, which are not handled in the Fleet Assignment step. Two different kinds of maintenance are considered; *minor* and *major*. The major maintenance activities are planned in advance and given as input to TAS. They usually require that the aircraft is on the ground for a long period of time and occur at long intervals, e.g. every 500 days the aircraft needs a thorough check. The major maintenance is a *preassigned* task, an activity that is fixed to a tail and the optimizer is not allowed to change. The minor maintenance activities are not fixed in time, but require that the aircraft get maintenance at some point in a certain interval. Minor maintenance typically requires less time on ground, often one night at the home base, and occur at more regular intervals, e.g. every 100 flight hours. Another typical requirement is that the aircraft should return to the base after a number of calendar days, in order to take care of minor defects. In addition to the maintenance regulations there are constraints on individual aircraft. Some aircraft might not be allowed to land at certain airports due to e.g. noise level.

2.1 Model

TAS can be modeled as a set partitioning problem.