Dynamic Assignment of Crew Reserve in Airlines

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ABSTRACT
The Crew Reserve Assignment Problem (CRAP) considers the assignment of the crew members to a set of reserve activities covering all the scheduled flights in order to ensure a continuous plan so that operations costs are minimized while its solution must meet hard constraints resulting from the safety regulations of Civil Aviation as well as from the airlines internal agreements. The problem considered in this study is of highest interest for airlines and may have important consequences on the service quality and on the economic return of the operations. A new mathematical formulation for the CRAP is proposed which takes into account the regulations and the internal agreements. While current solutions make use of Artificial Intelligence techniques run on main frame computers, a low cost approach is proposed to provide on-line efficient solutions to face perturbed operating conditions. The proposed solution method uses a dynamic programming approach for the duties scheduling problem and when applied to the case of a medium airline while providing efficient solutions, shows good potential acceptability by the operations staff. This optimization scheme can then be considered as the core of an on-line Decision Support System for crew reserve assignment operations management.

Keywords: Airlines Operations Management, Combinatorial Optimization, Crew Reserve Assignment Problem (CRAP), Crew Scheduling, Dynamic Programming

INTRODUCTION
The management of planning problems confronting logistics service providers frequently involves complex decisions. For more than four decades now the crew assignment problem (to flights, duties, reserve activities, etc.) of the airlines has captured the attention of the Management and Operations Research community since crew members management is extremely complicated and may generate many problems that hinder the smooth operation, influencing the total company operations profit (Rosenberger, 2001). Therefore for airlines the efficient management of their crew staffs is considered to be a question of the highest economic relevance. In the process of managing airline operations, once the scheduling of flights is performed by the commercial department and once the nominal crew assignment is completed, the problem of scheduling the reserve activities is raised. The latter activity is, first, to scale the size of the crew reserve and then allocate the available crew on reserve activities, taking into account the various constraints. In the case considered here, we assume that the solutions of the crew scheduling problem (CSP) and of the size of...
reserve problem are already established; thus, we focus our interest only on the assignment of crew to reserve activities. The amount of necessary investments and the high operational costs supported by the air transportation sector as well as its hard competitive environment, has led airlines to pursue a permanent improvement in their management practice at the planning and operations levels. With the deregulation policies adopted by the air transportation administrations of many countries, this goal has gained a major momentum. To meet their daily commitments, airlines assign or reassign their available crew to the scheduled or unscheduled flights and reserve activities while satisfying regulations and other operational constraints. When these assignments are done in an ineffective way, they have to support substantial overcosts which can impair their survival as a firm. The crew reserve assignment problem is then of considerable importance for airlines; and consequently, since the pioneering work of (Simpson, 1969), there has been a lot of research done to improve its solution (Yoshihara & Sengoku, 2000; Sohoni, Johnson, & Bailey, 2004; Liping, 2006). From the point of view of complexity theory, this problem is considered to be a difficult one since it presents a combinatorial choice within time and space dimensions with complicating ingredients from the operational constraints. It appears also that this problem is strongly related to the scheduling problem of crews duties (preventive medical visits, training, license renewal, etc.). Thus, a global solution for the crew reserve assignment problem is requested. In this communication a solution approach based on efficient enumerative methods is proposed to solve simultaneously these related problems.

In most airlines, the crew reserve assignment is established empirically. Sometimes even no crew reserve is planned, and operational problems are solved on time (Gaballa, 1979). The decisions are not optimal and can be very expensive. In fact, some operators spend little time on this task and have focused more on development of crew rostering. The development of crew reserve planning is often based on fixed ratios and the occurrence of specific events and periods (bridges between holidays, vacation periods, etc.). This leads to an availability of reserves approximately equal for each day of the month with the exception of those periods where the size of the reserve is increased. However, an effective crew reserve planning should allow airlines to cope with unexpected operational situations such as: failure of a crew (illness, delayed delivery, absence, late arrival of the crew at the airport, etc.), technical failure generating a change in aircraft type, strikes, and delayed flights (traffic congestion or bad weather) which prevents the crew scheduled for a flight to be available (Gaballa, 1979; Sohoni, Bailey, Martin, Carter, & Johnson, 2003; Sohoni, Johnson, & Bailey, 2004). The programming of crew reserve activities may affect the productivity of the airlines. An unused crew on reserve represents a loss of potential flight hours, but a higher loss is generated when no crew reserve is available and the call for a backup crew becomes unavoidable. The call for a crew who was given a leave is never desirable given the disruption it will produce in his personal life.

In our proposed approach, we introduce the CRAP as a mono-criterion decision problem where the criterion is representative of the additional crew operations cost. A set of hard and soft constraints are considered while solving the CRAP. This paper is organized as follows: an overview of research found in literature about this problem is presented; followed, by a mathematical formulation for this problem and a description of the proposed solution approach since the classical mathematical solutions approach present high complexity. Our proposed solution approach deals with the CRAP based on cost minimization using Dynamic Programming technique in order to build an efficient workload. We illustrate our solution approach with a numerical example applied to a medium size charter airline followed by discussion and analysis of the obtained results. Finally, we
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