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A Fast Heuristic for Airport Ground-Service Equipment-and-Staff Allocation

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Abstract

With the recent increase of air traffic, major airports become more and more congested: sensible delays may be caused by ground operations, and problems related to the efficiency and the safety of the apron area assume more and more importance. In this paper, we consider the problem of determining an efficient allocation of ground service equipment and staff to aircraft standing on the apron, as emerged in the framework of the European sponsored project "Integrated Airport Apron Safety Fleet Management – AAS". After providing a mathematical formulation for the problem, we suggest a fast sequential heuristic to be integrated in the real time dispatching decision support systems normally adopted in modern airports. The procedure has been applied in the AAS context, showing to be able to improve efficiency of handling operations.

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Keywords: Airport Ground Service Optimization; Sequential Heuristic; Network Flows

1. Introduction

The apron is the area of an airport where aircraft are parked and serviced from the time they land to the time they leave the assigned stand and taxi to the runways for take-off. Several operations take place in the apron (passengers and crew embarking/disembarking, refueling, cleaning and many others) and require both staff and Ground Service/Support Equipment (GSE), like steps, hi-loaders, follow-me cars, tow-tractors, baggage dollies, ground power units etc. GSE and staff have to be assigned to specific operations and moved to and from aircraft or parking positions. This may cause high levels of congestion, which may increase aircraft turnaround times and therefore increase delays and accident rates. It is thus not surprising that many different and interesting optimization problems have been the object of several studies in the last years (see, among others, Andersson et

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al., 2000), including aircraft-to-gate assignment, taxi planning, buses assignment, staff scheduling, GSE allocation etc. While specific research or even commercial tools are available for the gate assignment problem (e.g., Yan & Chang, 1998), staff assignment (Inform, 2009), buses allocation (van den Akker, Diepen, & Hoogeveen, 2008) or taxi planning (Roling & Visser, 2008), little attention has been devoted to GSE management. Recently, the European Commission has funded the project "Integrated Airport Apron Safety Fleet Management – AAS" (AAS Team, 2011), aiming at improving the efficiency and the control of airport groundside movements by advanced equipment and staff management. In this context, a procedure for robust assignment of GSE to apron operations has been developed (Andreatta et al., 2013), where a weighted sum of assignment cost and number of expected delayed tasks is minimized. In this paper, we consider the deterministic case of a more general problem consisting in determining an efficient allocation of both GSEs and staff, as suggested by the current practice in one of the major airports involved in AAS (Berlin Tegel – TXL). In the following, we state the problem, describe an integer programming model (Section 2), and present a fast heuristic approach (Section 3), which is our main contribution of the paper: we show how the problem can be decomposed into subproblems that are represented on a suitable flow network and efficiently solved as minimum-cost-flow problems. Then, we briefly discuss the application of the proposed procedures in the AAS context and give some final remarks (Section 4).

2. Problem statement, notation and basic mathematical formulation

We consider the set of aircraft expected on the apron in a given planning horizon (normally an entire day) for arrival, departure, turnaround, maintenance or other ground operations. For each flight, a set of *tasks* is defined, that is, a set of "simple" operations to take place during the ground time, e.g. "procure a front step to be used during passenger embarking", "use a tow-tractor to move the aircraft away from the stand", "bring a baggage-dolly to the aircraft and leave it there for all the requested time" etc. In particular, we consider the set Q of all tasks requiring both a staff member and a GSE. Q can be partitioned into *macrotasks* corresponding to disjoint subsets of operations that take place simultaneously around the same aircraft (for example arrival operations, departure operations, turnaround operations etc.). Let M be the set of macrotasks and $Q_m \subseteq Q$ the set of tasks associated with the macrotask $m \in M$. Staff members (set F) are grouped into *teams* and each macrotask m is assigned to a specific team. Let H be the set of teams and $F_h \subseteq F$ the staff members in the team $h \in H$. Let K be the set of *GSE types* (steps, tow-tractors, baggage dollies, ground power units, hi-loaders etc.) and E the set of the specific available GSEs. E is partitioned into subsets E_k, $k \in K$, and each task q requires one GSE of a given type, denoted by $k(q)$. The *Ground-service Resource Allocation Problem* (GRAP) consists in assigning a team to each macrotask and in determining a feasible allocation of one GSE and one staff member to each task, in order to minimize an appropriate score function.

2.1. The basic model

Several issues must be addressed in order to define feasible GSE-staff-task allocations, which will be discussed through the conceptual Integer Programming formulation of GRAP (IPGRAP) presented in Fig. 1. The model uses the following binary variables:

- y_{mh} taking value 1 if team $h \in H$ is assigned to macrotask $m \in M$, 0 otherwise;
- x_{ij}^{q} taking value 1 if staff member $i \in F$ and GSE $j \in E$ are assigned to task $q \in Q$, 0 otherwise;
- z_{ij}^{vwq} taking value 1 if staff member i is assigned to task v, GSE j is assigned to task w, and i and j are assigned to task q immediately after v and w, respectively, 0 otherwise.

In addition, the model uses the sets and parameters summarized in the following list: