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Check-in allocation improvements through the use of a simulation–optimization approach

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ABSTRACT

The aeronautical industry is still under expansion in spite of the problems it is facing due to the increase in oil prices, limited capacity, and novel regulations. The expansion trends translate into problems at different locations within an airport system and are more evident when the resources to cope with the demand are limited or are reaching to theirs limits. In the check-in areas they are appreciated as excessive waiting times which in turn are appreciated by the customers as bad service levels. The article presents a novel methodology that combines an evolutionary algorithm and simulation in order to give the best results taking into account not only the mandatory hard and soft rules determined by the internal policies of an airport terminal but also the quality indicators which are very difficult to include using an abstract representation. The evolutionary algorithm is developed to satisfy the different mandatory restrictions for the allocation problem such as minimum and maximum number of check-in desks per flight, load balance in the check-in islands, opening times of check-in desks and other restrictions imposed by the level of service agreement. Once the solutions are obtained, a second evaluation is performed using a simulation model of the terminal that takes into account the stochastic aspects of the problem such as arriving profiles of the passengers, opening times physical configurations of the facility among other with the objective to determine which allocation is the most efficient in real situations in order to maintain the quality indicators at the desired level.

1. Introduction

In spite of the increase in oil prices, limited capacity and novel regulations the aeronautical industry is still under expansion. This trend makes the efficient management of available resources at different levels in the airside or landside of an airport a challenging task. When the resources are not well managed problems arise and are perceived as congestions at different areas through the airport system. In the airfield they appear as queues in the runways with the corresponding delays; inside the terminals they are appreciated as huge queues in the security filters and in check-in counters. In addition they also cause excessive waiting times which in turn are valued by the customers as bad service levels. The aviation industry is just a link in the transport chain, but due to its importance in creating wealth not only for the tourist industry but also for the businesses it supports, good performance is critical for the development of regions and/or countries. Due to its yearly growth level of 5% (EUROCONTROL, 2008) it requires novel ways of improving the management of current resources without putting in risk important issues such as safety, quality or the environment at different levels.

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The traditional way of facing such problems has been just the expansion of the terminal facilities and the increase of resources at hand (i.e. addition of more counters, security filters or even new runways).

Besides the increase of flight traffic, there has been also an increase of the size of the aircraft used to transport the passengers and cargo. These conditions generate at the terminal level more potential congestions when the available resources are not efficiently managed (check-in counters, baggage handling systems, security filters, service vehicles, etc.).

On the other hand operation research techniques have been recently implemented in the aviation industry to cope with the problems aforementioned and to alleviate as much as possible the congestion problems. These techniques have been efficiently used in logistics or manufacturing fields because they are able to provide solutions that take into account several factors that hinder the proper management of systems. Hence, the solutions are more efficient than the ones that can be obtained by pure experience.

When these techniques are implemented for solving capacity problems in airport terminals it is necessary to take into account not only the natural quantitative limitations such as budget, limited areas for expansion, availability of resources but also the ones imposed by the internal policies which take into account metrics that are associated to the satisfaction of human beings. These metrics are called Level of Service indicators (LOS) and they measure characteristics associated with the perceived comfort inside the terminal such as available area per passenger, the speed at which the passengers can move inside the terminal, waiting times and queue lengths among others. Those metrics are of particular interest for airports that is the reason why focus has been put by scientific community to determine the factors that influence the perception (Correia et al., 2007) as well as techniques to measure them in a more objective way. Table 1 illustrates some of the typical values used by airports to evaluate their level of comfort inside terminal areas (DeNeufville and Odoni, 2003).

When the problems are properly modelled, the operation research techniques appear as the ones that are able to give solutions to a problem in a very efficient and fast way. Furthermore when these techniques are applied using a proper cost function the solutions can satisfy current restrictions and also they can generate solutions with high potential of improving the current performances.

It should also be mentioned that the use of optimization techniques are able to give optimal or close-to-optimal solutions to problems that are deterministic in nature; on the other hand simulation approaches have the advantages that they are able to describe the studied systems under different abstraction levels and can also consider the stochastic nature of the processes that participate in the system under study. However when simulation is used as a decision support tool it presents the disadvantage that it only explores a small subset of the whole possible scenarios that can be reached by the system under study thus reducing its optimization potential.

The current article presents a methodology that combines the two approaches and provides a better solution than the one that could be achieved by applying each technique independently. The methodology uses in the first phase of the approach an evolutionary algorithm in order to satisfy the quantitative restrictions such as minimum and maximum number of check-in desks per flight, load balance in the check-in islands, opening times of check-in desks and other restrictions imposed by the LOS. The initial solutions are encoded as chromosomes and some operations are performed in order to obtain the best promising solutions under a particular cost function. Once the initial solutions are obtained, they are in turn evaluated using a simulation model of the terminal under study taking into account not only the arriving profiles of the passengers but also the opening times, physical configurations of the facility and the interactions between passengers when they move inside the terminal. These elements are used to determine which allocation is the most quality-efficient in a close-to-real scenario in order to maintain the LOS indicators at the desired level. The proposed implementation has been developed using information of a real terminal but the methodology can be easily adapted to a different one with different restrictions imposed by the correspondent LOS agreements between the airport operator and the correspondent airlines.

1.1. A combined approach: evolutionary algorithms and simulation

In this section the basics of the main approaches are presented so that the reader has a clear understanding of the differences between them.

1.1.1. Evolutionary approach

The evolutionary approaches are techniques that fall within the so-called metaheuristics (Goldberg and Kochenberger, 2003). These techniques are able to provide “good” solutions in the sense that the developers of these techniques do not

Table 1
Level of service indicators.

Activity	Situation	Level of service (m^2/pax)					
		A	B	C	D	E	F
Waiting and circulating	Moving about freely	2.7	2.3	1.9	1.5	1.0	Less
Bag claim area	Moving with bags	2.0	1.8	1.6	1.4	1.2	Less
Check-in queues	Queued with bags	1.8	1.6	1.4	1.2	1.0	Less
Hold room	Queued without bags	1.4	1.2	1.0	0.8	0.6	Less