

Mitigating Airport Congestion: Market Mechanisms and Airline Response Models

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Abstract

Efficient allocation of scarce resources in networks is an important problem worldwide. The increasing demand for access to the world's major commercial airports combined with the limited operational capacity at many of these airports have led to growing air traffic congestion resulting in several billion dollars of delay cost every year. In this thesis, we study two demand-management techniques, strategic and operational, to mitigate airport congestion.

As a strategic initiative, auctions have been proposed to allocate runway slot capacity. An aspect of airport slot market environments, which we argue must be considered in auction design, is the fact that the participating airlines are *budget-constrained*. We focus on two elements in the design of such slot auctions – airline valuations and activity rules.

- The *preference elicitation problem* of finding the best bundle of slots on which to bid in an iterative combinatorial auction is a particularly hard problem, even more in the case of airlines in a slot auction. We propose an efficient valuation model (*Aggregated Integrated Airline Scheduling and Fleet Assignment Model*) to help airlines understand the true value of the different bundles of slots in the auction.
- Activity rules are checks made by the auctioneer at the end of every round to suppress strategic behavior by bidders and to promote consistent, continual preference elicitation. We show that the commonly used activity rules prevent straightforward behavior by budget-constrained bidders. We propose the notion of a *strong activity rule* which characterizes *straightforward bidding* strategies. We show how strong activity rules in the context of budget-constrained (and quasi-linear) bidders can be expressed as a linear feasibility problem.

We then study operational demand-management initiatives that are used when there are sudden drops in capacity at airports due to uncertainties, such as bad-weather. We propose a system design that integrates the capacity allocation, airline recovery and inter-airline slot exchange procedures, and suggest metrics to evaluate the different approaches to fair allocations.