Towards a Market Mechanism for Airport Traffic Control*

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Abstract. We present a multiagent decision mechanism for the airport traffic control domain. It enables airlines to jointly decide on proposals for plan conflict solutions. The mechanism uses weighted voting for maximizing global utility and Clarke Tax to discourage manipulation. We introduce accounts to ensure that all agents are treated fairly, to some extent. The mechanism allows an airport to determine the pay-off between optimality and fairness of schedules. Also, it compensates for agents that happen to be in practically unfavourable positions.

1 Introduction

Airports nowadays are more and more faced with air traffic congestions as a result of increased capacity demands. Much effort has been put into the development of software tools to assist the air traffic controllers in their decision-making process. These tools typically try to optimize a part of the planning on an airport, like the arrival and departure sequence and the gate assignment. Usually a strict hierarchy between planners exists to facilitate compliance to the several safety constraints. On the delay of an incoming aircraft, the arrival manager will typically replan its schedule first, to which the gate planner will adjust its schedule, after which the departure manager will adjust its planning.

A current trend in air traffic control (ATC) automation is that of distributed planning. An example is the Free Flight program [1,2], which enables aircraft to plan their own path of flight while communicating with aircraft around them to avoid collision. In the context of *collaborative decision-making*, a lot of work is done on information sharing between parties to increase quality of planning [3,4].

This article focuses on distributed airport traffic planning (ATP), i.e., the planning of the arrival, gate and departure process. We will look at the most important aspects of this planning and present a coordination mechanism by which aircraft can jointly decide on and enforce plan changes.

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2 Airport Traffic Planning

The planning of airport traffic starts months before it is executed. Based on the flight requests of airlines, provisional arrival and departure schedules are made. As time progresses and more information becomes available, these schedules become more and more detailed. On the day before execution the optimal gate assignment is determined and 'frozen', i.e., no more flight requests can be added. On the day of execution all flights are assigned *time slots*, 15 minute time periods in which they have to depart or arrive[1]. If a flight 'misses' its slot it has to request a new slot which is often not immediately available.

There are many reasons why things don't always go as planned. An aircraft might arrive at an airport later than planned, it might not be able to land on arrival because of congestions, a runway might be closed, etc. It might not be able to occupy its gate on time because the previous aircraft hasn't left yet. The *turn-around process* of an aircraft, the time that it is at the gate and is cleaned, refuelled, boarded, etc., might take longer than planned. It might not be able to depart on time because of congestion on the runway. And so on. It is up to the air traffic controllers to deal with these disruptions as efficiently as possible. This last phase of planning just before execution is called *tactical planning*. In general the main aim for ATC is to minimize the total amount of delay while complying with the safety constraints. The most important safety constraints are the separation constraints that indicate the minimal distance aircraft should maintain in different situations. Other constraints follow from taxi distances, ground services (catering, refuelling, cleaning, etc.), transfer passengers, etc. Of course flights should be kept within their timeslots if possible.

An important criterion for ATC to observe in the tactical planning phase is *fairness*. In case global plan changes have to be made because of disrupting circumstances, the different airlines should each bear an equal share of the burden. On a smaller scale, if at one occasion a flight from airline X has to be delayed in order to resolve a planning problem, the next time a flight has to be delayed it should be one from another airline than X. A factor that usually gets very little attention is the preferences of airlines themselves. It can very well be that an airline (or a group of airlines) prefers situation X over Y, while ATC has decided Y but wouldn't object to X. This might be because ATC doesn't have the time to research Y, or that it lacks information on the airlines' preferences.

In general, it is hard for ATC to assess plan change costs for airlines and thus to involve airlines' preferences. On the one hand ATC doesn't know exactly the state of affairs of an airline, its schedule details and dependencies needed to correctly assess plan change costs. Also, it is hard for ATC to compare for instance the costs of changing gates to changing runways. On the other hand, airlines can not and are not willing to give all the information ATC would need. They can not because this would result in a communication overload for ATC. They also don't want to give all their information because this can be disadvantageous to

[1] The fair allocation of slots to airlines is a challenging problem on its own, see for instance [5].