A Markovian Perspective of Airport Departure Process

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Abstract

The demand for aviation has been growing at an ever increasing rate. As a result there is an increasing pressure on airlines to operate more flights to cater to this demand. The key bottleneck in this process is the airport capacity. Airports, depending on their layout and size, have a stipulated capacity in terms of the number of aircraft they can handle in an hour. Increasing this capacity often involves creating new taxiways or increasing the number of runways which is capital intensive. The construction work might require a part of the airport to be shut down resulting in losses which adds on to the cost. Hence airports have a high inertia to increase capacity.

At most major international airports it is observed that operational capacity is much lower than that of the actual airport capacity. The operational capacity can be as low as 83% of the actual capacity at some airports. This gap suggests that there is huge potential to increase the number of aircraft handled by an airport without increasing its physical capacity. This inefficiency arises due to several factors such as irregular pushback rates, adverse weather conditions and arrival traffic congestion.

Our work proposes to model the aircraft departure process as a Markov chain to estimate the time a particular aircraft would require to take off starting from the departure terminal. The model takes into account the departure demand, arrival throughput and weather conditions. The departure demand and the arrival throughput are given as parameters while the weather conditions are provided by using a well established surrogate metric, Route Availability Planning Tool. We calculate the mean time spent at each transient node to predict the time it will take for the flight to takeoff from the time it leaves the terminal. Given that our model considers each departure terminal, taxiway and runway as nodes, it is agnostic to the specifications of the airport. It can be applied to an airport containing multiple runways. Another feature of our model is that it provides a comprehensive estimate which includes pushback delays and the time taken on the runway. This eliminates the need to assume some probability distributions for the same.

The model is used to predict the departure times of aircraft at three international airports, viz. John F. Kennedy (JFK), Newark Liberty (EWR) and Philadelphia (PHL) using the data collected from FAA's Aviation Systems Performance Metrics (ASPM) database.

Our model can be used to provide an accurate estimate of the time to departure for every aircraft enabling them to schedule pushbacks in an efficient manner. An efficient pushback schedule, which is fully informed of the arrivals and weather conditions, will minimize the time the aircraft spends taxiing, increasing the operational capacity of the airport.

Keywords

Airport, Congestion, Scheduling

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Biographies

Ch V Sai Praveen is a pre-final year undergraduate student pursuing Bachelors in Mechanical Engineering and Masters in Financial Engineering. He has worked on several projects involving machine learning and optimization with applications spanning diverse domains. He possesses a keen interest in stochastic modelling of common processes and optimizing them.

Mayank Anand is an undergraduate student, pursuing a B. Tech course of Manufacturing Science and Engineering in Department of Mechanical Engineering, Indian Institute of Technology Kharagpur. He has worked in the field of reverse logistics with an objective to optimize operational cost of supply chain incorporating environmental and sustainable issues. He is currently working on the mathematical modelling for resilient close-loop supply chain immune to network and operational disruptions. His research interest lies in modelling complex industrial issues and solving it using various algorithms.