Abstract

In this work we address simultaneous scheduling of aircraft and crews under consideration of disruption. These tactical scheduling tasks are usually performed several months prior to the day of operations. Both schedules are easily disrupted on the day of operations, because of restrictions on maintenance of aircraft and working time of crews. These disruptions are hard to recover and often lead to additional delays. Both problems are also closely interdependent due to crews changing aircraft on the day of operations. Such aircraft changes can lead to additional propagation of delays between aircraft, i.e. following the crew from one to another aircraft.

We present an integrated stochastic model for aircraft assignment and crew pairing with the objective of minimizing planned crew costs as well as total delay propagation between aircraft and crews. We propose to solve the integrated model heuristically by decomposing it into separate stochastic problems for crews and aircraft, modelling the interdependencies of the two problems by a common objective function and applying an iterative solution approach. We develop a branch-and-price-and-cut method for the deterministic and stochastic tactical scheduling problems for crews and aircraft. The pricing subproblems are modelled as resource-constrained shortest-path problems and solved by a dynamic programming approach with a new backtracking scheme as well as a new label categorizing technique. The heuristic solution approach enables us to generate robust aircraft and crew schedules for weekly scheduling problems with more than 250 flights in less than four hours. The main property of the stochastic problems resulting from our decomposition is that the delay scenarios only need be considered in the subproblems. We show that the additional constraints modelling delay propagation can easily be modelled by the resource constrained shortest-path problem and thus enable us to reuse existing dynamic programming methods in the pricing subproblem.

We present a simulation model as well as a framework within which to compare different approaches for robust scheduling. With this framework we compare the stochastic scheduling approach with a similar deterministic approach to robust scheduling. The deterministic approach penalizes short slack between two flights if the crews are scheduled to change aircraft. The deterministic model does not consider any delay scenarios or delay propagation and thus leads to shorter solution times. We evaluate the approaches by computing the operational performance of schedules. The later is measured by simulating crew and aircraft schedules and comparing the number of reactionary delays as well as the number of crew duty disruptions, which are not resolved by delay propagation. The predictability and efficiency of both approaches is very high. The deterministic model, however, need extensive calibration in order to reach these good results.

Moreover, we propose an approach to rescheduling aircraft and crews on the day of operations, which is based on the developed optimization methods. The presented approach solves the recovery problems for crews and aircraft iteratively using flight retiming. The proposed decomposition of the integrated problem leads to a reduced complexity and therefore to lower solution times of the iterative approach than with methods for the integrated problem.