Abstract of the Thesis

Flottenzuweisung in der Flugplanung: Modelle, Komplexität und Lösungsverfahren

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In this thesis we present and analyze some aspects of the planning process of an airline, especially the *airline fleet assignment problem*, which has to decide what kind of aircraft should operate each flight of an airline schedule. The optimization algorithms described in this thesis have been integrated into commercial decision support systems, where they successfully help to improve the quality of the aircraft schedules for several airlines.

The airline fleet assignment problem is a hard optimization problem. Given the sets of flights and aircrafts of an airline, the fleet assignment problem consists in assigning the most profitable aircraft type to each flight. In doing so, each flight must be operated by exactly one aircraft type and the total number of aircrafts needed by the assignment must not exceed the number of available aircrafts.

We prove new *complexity results* for the fleet assignment problem. The main result shows that the fleet assignment problem with two aircraft types is strongly NP-complete and cannot be approximated in polynomial time (if P is not equal NP). Furthermore, we complete the known results about the complexity of the fleet assignment problem by considering the acyclic variant and some extensions like connection dependent revenues.

We present new *exact and heuristic optimization algorithms* for the fleet assignment problem. The exact methods use integer programming formulations of the problem that can be solved by standard IP solvers like CPLEX or CBC. We introduce several new IP models for the basic fleet assignment problem and extended variants. The heuristic solution methods are local search algorithms. They use a new problem specific neighborhood for the fleet assignment problem that allows finding near optimal solutions in short time.

By using *stochastic input data,* i.e. for the duration of a flight, more robust plans can be generated, that can be repaired more easily if disruptions occur. We show that the stochastic fleet assignment problem is PSCPACE-complete, though. It can be modeled as a game against Nature that can be solved (heuristically) with the help of an extended game tree search algorithm. Experimental results show that these heuristic solutions are superior to exact solutions of non-stochastic models of the fleet assignment if disruptions occur during operations.

By *integrating fleet assignment with market modeling and revenue management* the achievable revenue of a fleet assignment solution can be calculated more accurately. We present several strategies how to integrate our local search heuristics for the fleet assignment problem with market modeling and revenue management. It turns out that the actual achievable profit of a fleet assignment can be increased considerably by these integration strategies.