Group Construction for Airline Cabin Crew:
Comparing Constraint Programming with Branch and Price

Jesper Hansen¹ and Tomas Lidén²

Carmen Systems
¹ Købmagergade 53, DK-1150 København K, Denmark
² Maria Bangata 6, SE-118 63 Stockholm, Sweden
{jesper.hansen, tomas.liden}@carmensystems.com

Abstract. Producing work schedules for airline crew normally results in individually different schedules. Some airlines do however want to give the same schedule to groups of people. The construction of such groups must respect certain rules, provide a good matching of certain factors and fit well into the normal process of producing anonymous trips starting and ending at the home base and assigning these to the crew. In this paper we present an application, implemented and delivered to a large European airline, which addresses these needs. The problem is challenging to solve for certain cases. Hence two different approaches have been applied, one using constraint programming and the other using column generation. These two methods are described and compared – along with computational results.

1 Introduction

Constructing work schedules for airline crew is typically divided into a crew pairing problem and a crew rostering problem. In the pairing problem anonymous pairings, or trips starting and ending at the home base, are constructed from the flight legs such that the crew need of each flight is covered. Following the pairing construction, the pairings are assigned to individual crew together with other activities such as ground duties, reserve duties and off-duty blocks, to form rosters. For more information on crew pairing and rostering we refer to the surveys of Andersson et. al. [1] and Kohl and Karisch [7].

Some airlines want to give the same work schedule/roster to a group of cabin crew members (purser and cabin attendants). This is to ease planning, increase the robustness of the schedule and for social reasons. Constructing such groups can be done before the rostering step. Then, a representative person from each group (normally the purser) is assigned a roster by the crew rostering system, which is then copied to the rest of the group members. If the group has been poorly formed, it will not be possible to copy all pairings. For example, if one crew member has a pre-assigned duty (e.g. course), a pairing touching that day cannot be assigned. Such “drop-out” pairings must be resolved manually.
The construction of crew groups should therefore be solved so that the number of problems to handle in successive steps is minimized (both for the current scheduling period and future ones). Thus we want to achieve “homogenous” groups.

An application solving the crew-grouping problem has been developed and delivered to the Spanish airline Iberia as an addition to the Carmen Crew Rostering system. It has been used in production since spring 2002. Each problem instance solved includes 300-1200 crew and results in 30-200 groups of 3-13 persons each.

There are several approaches to formulating and solving this problem. The first delivered version used pure Constraint Programming (CP) [2]. During spring 2004 a second version was delivered based on Column Generation (CG) where the generation makes use of CP techniques (enumeration with some simple look-ahead domain reduction). The idea of combining CG and CP is not new (see e.g. Junker et. al. [6]) and many papers have been dedicated to comparing Integer Programming and CP methods for various applications. Grönkvist [4, 5] for instance, compares the methods on the Aircraft Scheduling Problem.

The initial reasons for choosing CP were the uncertainty of the problem formulation and constraints involved. Further the initial descriptions indicated a highly constrained problem including non-linear constraints and objectives. The need for modeling flexibility and a restricted budget were also important factors.

During the elaboration and development of the CP version the problem proved to be less constrained than anticipated and turned out to be more of an optimization problem than a feasibility problem. The idea of a mathematical programming formulation started to evolve and was investigated in a master’s thesis work [3]. The results were good, however not all issues were considered. Hence it was decided to develop a CG version. The normal cases (January-November) to be introduced in the following were easily solved, but the “December” problem for the medium and large fleets proved to be surprisingly hard to solve. Thus the development of several advanced features was needed, such as stabilized column generation [8], and branch and price using constraint branching [9]. All these features along with a careful tuning of parameters have been necessary in order to achieve the goal of finding better solutions within similar or shorter execution times.

After giving a problem description, the pure CP model is described followed by the CG model. In sections 4 and 5 the solution procedures are outlined. In section 6 we describe the special considerations for the month of December. Computational results are presented in section 7 along with discussions on the suitability of the different methods, properties of the problem and alternative approaches. We end with a conclusion in section 8.

2 Problem Description

The problem is basically to assign crew members to groups such that the best possible matching is achieved minimizing the exceptions to handle when assigning schedules to the groups. The number of crew per group depends on the aircraft type. The cost factors in the matching problem are: