A Case Study for Timetabling in a Dutch Secondary School

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Abstract. This paper describes a case study for constructing the yearly schedule of a secondary school in the Netherlands. This construction is divided in three steps. In the first step we create cluster schemes containing the optional subjects. A cluster scheme consists of cluster lines, and a cluster line contains classes which will be taught simultaneously. Part of the problem is that the students are not yet assigned to the classes. Once the cluster schemes are fixed, it remains to schedule the lessons to time slots and rooms. We first schedule the lessons to day-parts, and once this is completed we schedule the lessons to time slots within the day-parts. Thanks to consistency checks in the day-part phase, going from day-parts to time slots is possible. Finally, in the third step, we improve the previously found schedule by a tabu search using ejection chains. Compared to hand-made schedules, the results are very promising.

1 Introduction

In the past 25 years a lot of research has been done on automated High School Timetabling. This research can be divided in two groups:

1. Theoretical oriented research and surveys, see for example, in chronological order [5,7,9,18,21,23,24]. These papers either define some concepts and/or methods, but do not describe real-life implementations.
2. Research based on several cases (usually high schools from the region). These papers (hopefully) define the problem they study, and explain that their methods perform quite well on the real-life cases considered. Examples of these papers are found below.

What is apparent from the studies in the second class, is that the problems differ widely among the countries. Of course, there are certain aspects that they all have in common. This could be named the basic high school timetabling feasibility problem replacing 'lesson' by 'event', this is the basic timetabling problem):

E.K. Burke and H. Rudová (Eds.): PATAT 2006, LNCS 3867, pp. 267–279, 2007.

Given a set of lessons with needed resources, and time slots,

Assign resources and a time slot to each lesson, such that the resources are not over-used.

We assume the situation that we need to construct a schedule for a week, which is repeated for a certain period like a year or semester. A lesson has usually the following resources with restrictions:

1. *Class*: the (virtual) group; can be used once per time slot. There are two principally different situations:
   - The classes are mutually disjoint: every student is in exactly one class. This is called the 'Class–Teacher model'.
   - The classes are not disjoint: the class depends on the subject (students have optional subjects). This occurs for example in Germany [4,11,25], the Netherlands [12,26], and New Zealand [27].

   In the first case, some intermediate cases can exist, where several classes are combined and reshuffled based on level (easy math vs. difficult math), or religion, or sex (physical education lessons).
2. *Subject*: the subject of the lesson; the (subject, class) combination can be used once per day.
3. *Students*: the students that constitute the class of the lesson; a student can be used once per time slot. In most countries the students are preassigned to the class. However in case of optional subjects, these students might have to be divided over different classes (the Netherlands: [12,20,26]).
4. *Teacher(s)*: the teachers of the lesson; a teacher can be used once per time-slot, if the teacher is available at that time. Usually a lesson has just one teacher, which in most countries seems to be preassigned, while in some it has to be assigned, for example in Australia [1], Greece [6], and the UK [28].
5. *Room(s)*: the rooms needed for the lesson; a room can be used once per time slot. Usually the lesson needs only one room, and this room has to be assigned; some papers mention that a class has its own room (Greece [22], Italy [19]). (Another possibility is that only room types – like music-room, gymnasium, etc. – are assigned.)

From this we see that already the basic feasibility problem has several variants: assign students or not, assign teachers or not, assign rooms or not.

As far as the objective function is concerned, the variants are even more diverse. Here we mention two cases, which sometimes appear as hard constraints:

1. Compact schedules for classes, which means schedules for classes without idle times. Here an idle time (for a class or teacher) is defined as a free time slot between the first and last lesson of the day. In several cases this is automatic, as a class has as many lessons as timeslots available, as in Brazil [16,17], Italy [8,19], Spain [3], Switzerland [10], and the UK [28]. In cases with optional subjects it is usual impossible to have compact schedules. These schedules, on the student level now, are not often considered for quality.