A Comprehensive Course Timetabling and Student Scheduling System at the University of Waterloo

Michael W. Carter,
Mechanical and Industrial Engineering,
University of Toronto,
5 Kings College Road,
Toronto, Ontario, Canada
M5S 3G8
carter@mie.utoronto.ca
http://www.mie.utoronto.ca/staff/profiles/carter.html

Abstract. This paper describes a comprehensive course timetabling and student scheduling system that was developed for the University of Waterloo between 1979 and 1985. The system is based on a “demand-driven” philosophy where students first chose their courses, and the system tries to find the best timetable to maximize the number of satisfied requests. The problem is first decomposed into small manageable sub-problems. Each sub-problem is solved in sequence using a greedy heuristic to assign times to sections, and a Lagrangian relaxation algorithm to assign classrooms. Timetable representatives from each department have interactive access to make final modifications. Finally, each student is individually assigned to the combination of course sections that maximizes timetable satisfaction and balances section sizes. The system has been used successfully for 15 years.

1 Introduction

For the purposes of this paper, course timetabling and student scheduling will be defined as the sequence of problems where each meeting of each course is assigned to a classroom and a time, and students are assigned to sections of each course such that they have no conflicts. At Waterloo, we did not automate the assignment of faculty to course sections; that process is normally done manually in advance.

Although the system was implemented 15 years ago, much of the discussion is still very relevant. In a recent survey of practical course timetabling, Carter and Laporte [6] observed that there were very few papers published that described actual implementations of course timetabling. Aubin and Ferland [1] describe a method that used quadratic assignment formulation for both course timetabling and student sectioning. The program was implemented at a large Montreal High School and two university departments (although they did not provide details on the implementation). Paechter et al. [9] and Rankin [10] describe a genetic course timetabling algorithm that is being used for the Computer Science Department at Napier University. Sampson et al. [11] describe a heuristic that was implemented in the Graduate School
of Business at the University of Virginia. The existing university examples were all restricted to a single department or school. There are no published examples of an automated, integrated course timetabling system across the institution. We believe that researchers in practical timetabling can learn a lot from this case.

The University of Waterloo is a comprehensive university with undergraduate and graduate programs in Applied Health Sciences, Arts, Engineering, Environmental Studies, Mathematics and Science. The University offers North America’s largest co-operative education program that operates year-round, as well as the more traditional regular program of two consecutive four-month school terms. [12]

In 1985, there were 17,000 undergraduate students and has now grown to close to 20,000. In the Fall term of 1985 (the term we used for our parallel testing and benchmarking) there were 1,400 courses offered with about 3,000 course sections. (i.e. some courses have multiple sections.)

The system required an estimated 40 person years (1979~1987) to develop. It was designed to run on IBM mainframe equipment, and the database and the programs were all developed in-house. The new system required about 100 new programs to be written and 400 old ones changed. It was implemented between Aug 1985~May 1987. One of the drawbacks of the system is that it has been designed to solve the specific instance of the Waterloo problem; it is not portable, although many of the optimization routines were designed to solve a more general mathematical problem.

In spite of the fact that the system is over 15 years old, we believe that there is still no system that solves the large-scale course timetabling problem with this level of mathematical sophistication.

2 Overview of the System

In North American schools, it is common for students to choose courses from a wide variety of electives. This is particularly true for the humanities and social sciences, but there is often considerable flexibility in upper year science and engineering programs. Waterloo uses a “demand driven” timetabling system: students pre-register for courses from a list of “course offerings” posted in March. The University then constructs a timetable that attempts to minimize potential student conflicts (see Carter and Laporte [6] for a discussion of demand driven timetabling versus master timetabling where the course times are fixed first, and then students pre-register.)

The key milestones in the timetabling/registration cycle (for Fall term) are as follows:

- March: student pre-registration: students submit a list of course requests.
- Early June: initial timetabling: each course is assigned to a day/time slot; initial room assignment: each meeting is assigned to a classroom.
- August: initial student scheduling: students are assigned to course sections.
- September: on-line scheduling: students revise schedules in a “drop/add” period.