Untis Course Optimization for Finnish High Schools

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Abstract. Untis has provided scheduling software for schools worldwide for over 50 years. In recent years, the optimization team at Untis, in collaboration with IMC Krems University of Applied Sciences, has developed new approaches to course optimization. In this talk, we present one such approach: a course optimization for Finnish high schools. The solution is currently deployed and in operational use across multiple Finnish schools.

Finnish high schools operate under a distinctive timetabling regime: a fixed master timetable, shared across all schools in a district, assigns time slots to clusters across multiple terms. A cluster is a set of courses that take place at the same time. Because time slots are aligned district-wide, students can attend courses at neighboring schools during the first and last periods of the day — a feature rarely seen in other countries. These circumstances significantly shape the resulting optimization problem.

The course optimization problem in this setting is a variant of student sectioning: given a set of students with their course choices, a set of courses, terms, and a fixed number of clusters, assign each student to set of courses and each course to clusters and terms so as to minimize the total number of student conflicts, subject to constraints such as:

– Each student is assigned to at most one cluster per time slot (no conflicts).
– Each teacher is assigned to at most one cluster per time slot. Teachers are preassigned to courses.
– Each room type has a limited number of rooms available per time slot, and each course requires specific room types.
– Each course must be assigned to exactly one cluster per term it takes place in.
– A course spanning multiple terms must be assigned to clusters in consecutive terms.
– Certain courses must be completed by a student in a prescribed order (prerequisite constraints).
– Certain courses must be assigned to the same clusters.

We formulate the problem as a mixed-integer program (MIP). However, real-world instances with up to 1500 students and 5-6 terms per academic year cannot be solved directly by state-of-the-art commercial and open-source MIP solvers (Gurobi, CPLEX, OR-Tools). The main difficulty is the lack of decomposable structure: in practice, student course choices always overlap across class levels and topic groups, preventing

partitioning into independent subproblems. Furthermore, dependencies between terms restrict the decomposability.

Our approach combines column generation with large neighborhood search (LNS). We select the initial set of representative students to cover the most constrained cases first, while ensuring that all course types and prerequisite course chain variants are represented. We solve the restricted MIP, analyze the solution to identify violated constraints, and iteratively add students. The LNS phase then improves the solution, considering all students simultaneously. For many real-world instances, this approach finds optimal or near-optimal solutions in under 60 minutes. This results in a significant reduction in planning time for the schedulers.

We have also developed a validation layer that detects infeasibilities and conflicts before optimization. This component has proven essential in our deployed system, where schedulers need actionable feedback to adjust inputs when constraints cannot be satisfied.

In the talk, we present the MIP formulation, discuss why standard decomposition strategies fail for this problem class, describe the validation layer, and show computational results for schools with 300-1250 Students and practical experiences from our deployment at Finnish schools.

Keywords: Student sectioning · Course timetabling · Column generation · Large neighborhood search · Mixed-integer programming.