

An abstract formulation of the problem of timetabling

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Purpose

1 A summary of existing formulations

Most information from this section can be found in arXiv:2201.07525v1.

1.1 Post - Enrolment Course Timetabling (PE-CTT)

In *PE-CTT* a set of events, a set of periods, and a set of rooms are given. Time partitions are also specified, in terms of days and periods such that each period is a timeslot belonging to one day.

Then there are also requirements:

1. there is a set of room features that may be required by events. Room features and capacity (in terms of seats) together result in a compatibility relation between rooms and events.
2. In addition, a precedence relation between events is also provided. Some events must be scheduled before others...
3. Finally the last constraints are the ones originated from an unavailability relation stating that an event cannot be scheduled in some specified periods.

The objective function is composed by three components that penalize the following cases:

1. A student attending an event in the last timeslot of a day.
2. A student attending three (or more) events in successive timeslots in the same day.

3. A student attending only one event in a day.

1.2 Curriculum - Based Course Timetabling (CB-CTT)

A note on differences: The main difference between the previous formulation and this stems from the notion of a course as a set of lectures that is absent in PE-CTT. Many constraints and objectives in CB-CCT are defined at the level of a course, whereas in PE-CTT constraints and objectives are always expressed at the level of the single event / lecture. We consider the variant of this formulation introduced in ITC-2007.

Short specification:

- Each course consists of a fixed number of lectures to be scheduled in different periods.
- We are given a number of periods divided in days and timeslots in the day.
- Each room has a capacity, specified as the number of available seats, but no other feature.
- A curriculum is a group of courses that potentially have students in common. As a consequence, lectures of courses belonging to the same curriculum are in conflict and cannot be scheduled in the same period. *two courses are also in conflict if they are taught by the same teacher.*
- The hard constraints involve: conflicts, teacher availability, and room occupancy.
- The objective function (soft constraints): is composed by four components that penalize the following cases:
 1. The capacity of the room assigned to a lecture
 2. The lectures of a course are not spread into the given minimum number of days.
 3. The lecture is isolated i.e not adjacent to any other in the same curriculum.
 4. The lecture of a course are not given all in the same room.

1.3 More complicated formulations

High - School Timetabling (XHSTT) and University Course Timetabling (ITC-2019) are two formulations which are substantially more complicated than the ones discussed till now. This is primarily due to the fact that these formulations try to reduce the gap between an idealized and simplified problem to one that is actually encountered in practice. We omit specifying these formulations in brief as that would simply not be possible.

2 A generalized formulation

2.1 Terminology

Students and faculty members carry there normal informal meanings

2.1.1 Party

A party is defined as a set of students or faculty members but not a set containing both. In this way the distinction between members of faculty and the student body enters the formulation.

2.1.2 Time Cycles

A time cycle is defined as the total duration in which a time table can be specified. This is usually a week. The time table is repeated the start of each new cycle.

2.1.3 Day

A day is a subinterval of the time cycle. Requirements periodically repeat in a day. I.E times where nothing can be conducted.

2.1.4 Time slot

A subinterval of the day.

2.1.5 Period

A period is defined as the following 3-tuple (P_s, P_f, t) where P_s is defined as the party of students, P_f is defined as the party of faculty members (which is usually singleton), and t is a timeslot. *Note: Parties could be empty*

2.1.6 Course

A course is defined as the *3-tuple*: $(\{P_s\}, \{P_f\}, P)$ where P is a set of periods. Requirements of periods are specified, not for the entire semester, but only for one time cycle.

2.1.7 Curriculum

A curriculum is a set of courses such that there exists a party of students who are enrolled in all and no more courses than those specified in a curriculum. It is defined as the following *2-tuple*: $(P_s, \{c\})$ such that $P_s \succ c \forall c \in \{c\}$.

2.1.8 Room

A room is meeting place where a period takes place. It can be fully described by its capacity.

2.1.9 Requirement

2.1.10 Timetable

A time table is defined as the following mapping:

$$f : \{C\} \times \{t\} \rightarrow P$$

where $\{C\}$ is the set of all curriculums (or partitions of curriculums), $\{t\}$ is the set of all timeslots, P is defined as the set of all periods, and f satisfies all requirements.

2.1.11 Objectives

2.1.12 Optimal Timetable

2.2 Formulation