Conflict inheritance in sectioning and space planning

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Abstract In timetabling of large groups we may need to both split events into smaller events, and also to assign students to these events. We investigate the interaction between these from a space planning perspective, and in particular, the effects on the effective conflict matrix.

1 Introduction

Universities have to carry out space planning to provide appropriate space for changes in curriculum structure and to adjust to changes in projected student numbers. This space planning also needs to achieve a good value for the cost of space resources, yet allow academic service quality to be maintained. Such planning is generally affected by the various constraints of course timetabling (Schaerf 1999; Carter 2000), and we have developed methods for space planning in this case (Beyrouthy et al 2007b). However, when there are large student groups then "timetabling" also needs to take account of:

- *splitting*: taking large events and splitting them into smaller sections. The space planning aspects of this were studied in Beyrouthy et al (2007a).
- *sectioning*: the act of assigning students to sections, see for example Murray and Müller (2007).

Generally, these issues also interact with the timetabling constraints. Whilst such interactions have been studied in sectioning problems (see Schaerf (1999)) they have not been addressed simultaneously; that is a splitting/sectioning framework together with considerations of the interaction with space planning. Here, we report on work to remedy this deficiency.

It is generally expected that sectioning will help resolve the timetabling conflict constraints. Specifically, we will use the term "partial inheritance" as a measure of the extent to which conflicts are transmitted from "parent" classes to "child" groups as splitting and sectioning take place. Consider, as an example, when splitting conflicting classes "A" and "B". There are two extreme cases: "full inheritance" when all sections of A are taken to conflict with all sections of B; and, "zero inheritance" when none of the sections of A are taken to conflict with B. In general, some intermediate

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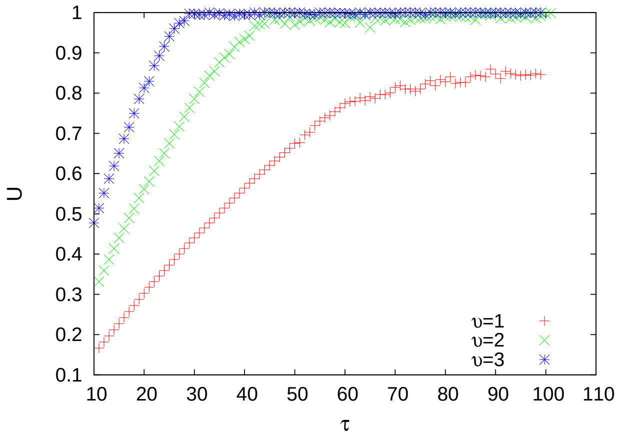
Fig. 1 Utilisation (U) versus upper limit on group size (τ) for different upper limit on the group number (ν)



inheritance can be expected, however, it is hard to quantify this. Consequently, working purely at the level of splitting is hampered by the lack of a way to quantify the extent of this effect. Here, instead of trying to directly measure these effects, we focus directly on the effect on space allocation.

Specifically, we ask whether or not the "partial inheritance" is effectively zero; by which we mean that conflicts are sufficiently resolved that the events can all be allocated. This work investigates the extent to which the timetabling conflicts are reduced, and provides cases where their effects are reduced to zero.

Strictly speaking, it might be considered wrong to say that no conflicts are inherited. It is perhaps more accurate to say that the results are the same as if none had been inherited; so the partial inheritance is effectively zero. That is, as far as space planning is concerned, we could have done splitting at the course level and ignored timetable conflicts between the resulting sections. This reflects a general issue that we are (implicitly) investigating here. It is not automatically necessary that the timetabling problem used during space planning needs to represent the full timetable problem, but rather could be a simplified one.

Hence, here we report on experimental studies of: (i) the interactions between space planning, splitting and sectioning, (ii) the issue of "partial inheritance."

2 Partial Inheritance and Utilisation Results

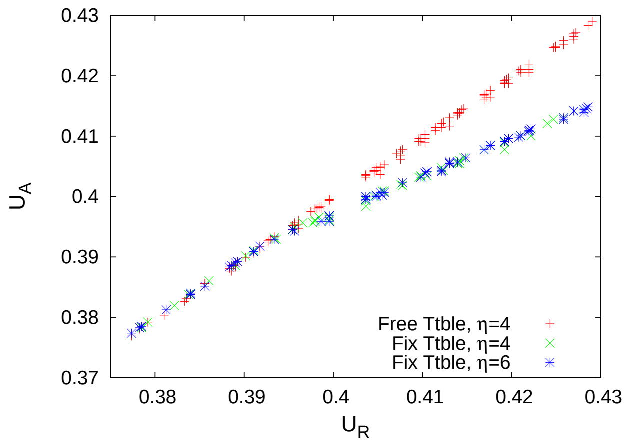
This work differs significantly from our previous work in splitting (Beyrouthy et al 2007a) in that it is student-centered, with modelling of individual students. Sectioning decisions are made, assigning individual students to groups or sections as well as constructing a class timetable. Other than this, the objectives and constraints are similar to those of Beyrouthy et al (2008).

To connect the issues of partial inheritance together with space management, we measure whether or not a set of courses have a splitting and a student assignment such that a conflict-free timetable exists. In such a case, we will say that the partial inheritance is (effectively) zero. We will look at when this occurs as a function of various parameters; of which the only ones we need here are:

– ν: the upper limit on the number of groups per class
– τ: the upper limit on the size of each group

(See Beyrouthy (2008) for an in-depth study of the parameters, and a richer terminology).

Fig. 2 Robustness of the Partial Inheritance at the special pair (τ, ν). $\tau = 42$ and $\nu = 2$. Plots with different values of the number, η, of enrolments per student for free and fixed timetable.



In our approach we start from: a fixed instance of classes and rooms; a given student enrollment; and a fixed timeslot number. We then vary the upper limit on the *group size* τ and plot the utilisation versus τ for different values of upper limit on group number ν. For each set of courses, student enrollments are artificially generated by a "window-based generator" (Beyrouthy 2008). An example of the results is given in figure 1 (the data-set in this case is a set of workshops). When no splitting is allowed, $\nu = 1$, there is no full allocation, i.e. $U < 100\%$, for any value of τ: conflicts remain unresolved and the effective partial inheritance is non-zero, However, when splitting is allowed, $\nu > 1$, then the situation is very different. For $\nu = 2$, after a given value of τ (≈ 42) full allocation becomes possible. Similarly, when $\nu = 3$ all values of $\tau \geq 30$ make full allocation possible, that is, the partial inheritance is zero in the sense that all the conflicts are resolvable.

In figure 2, we plot the requested versus achieved utilisation for fixed values of τ and ν. Every point in the graph represents a single solution, and basically gives the number of seat-hours that can be successfully allocated as a function of the number requested (for details, see Beyrouthy et al (2007b,a, 2008)).

3 Timetable Robustness

Universities have the option of whether or not to change their timetable as a response to student enrollments. In order to quantify the effects of such decisions on space planning, figure 2 compares the previous case of a freely selectable timetable with a fixed one. Leaving the timetable freely adjustable,(`Free Ttble`), shows that almost every requested utilisation has been fully achieved: Changing the timetable for every instance helps resolve all the conflicts. In contrast, in the other plots, (`Fix Ttble`), we fix the timetable and find that after a given critical utilisation level, not all requests can be achieved. (In this case, we also give results for two values of η used by the enrollment generator to show that conclusion is not affected).

4 Conclusion

This work reports a study of the interaction between space planning, splitting and sectioning. It also studies the partial inheritance concept of how conflicts are transmitted from classes to group splits when splitting and allocation occurs. Using our student enrolments generator we showed cases where all (or almost all) of the conflicts were resolved as more group splits were allowed. We have also studied the space planning effects of fixing the timetable rather than allowing it to vary. In our example, this resulted in a 5% drop in the requested utilisation. In a large institution such a drop could have significant cost implications, and so such effects need to be considered when space planning.

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