Evaluating the space planning benefits of partitionable rooms

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1 Introduction

In many real world situations, it would be easier to find feasible timetables if a room had movable partitions; allowing it to be used either as multiple rooms or as a large single room. We propose methods to evaluate the potential benefits for timetabling and space planning of having such rooms.

In recent work, (Beyrouthy et al 2006, 2007b,c, 2008a), we developed methods designed to support better space planning within universities. The core problem is to plan the provision of space resources for future terms or semesters, such that when the timetabling of events is finally performed, then sufficient appropriate space is available. However, for cost reasons, is it important to do this without overestimating the need for space.

The standard measure of space usage is utilisation: simply put, this is the fraction of available seat-hours that are actually used. In many cases, the utilisation is found to be low i.e. between 20-30% (HEFCE 1999). The long-term goal of this research is to provide decision support methods that will improve this situation. The methods currently developed exploit the appearance of thresholds within a sampling-based method. In particular, given a set of candidate events (representing the set of likely futures), they identify a critical utilisation, for a given set of room resources, that limits the total number of events that can be reliably scheduled. In related work (Beyrouthy et al 2007a), we show how the room sizes can then be selected so as to increase this critical utilisation.

In some circumstances, the space planner might appreciate having the option to consider having rooms that are partitionable. That is, rooms with a physical partition that can be removed when desired. For example, the partition might simply slide to one side. Typically, such a partition will have higher costs than a simple fixed internal wall. In addition to the potentially higher capital outlay, there will be labour costs to move it when needed, and, inevitably, also maintenance costs.

In return for the higher costs the space planner would expect benefits in terms of the ability to find space for the events that will occur during the lifetime of the room. The benefit of a partitionable room is that when the divider is closed then it functions as two separate, though smaller, rooms rather than one single room; effectively, giving one more room for events. (The partitions might even

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correspond to different space types e.g. one larger partition and one smaller could be classified as lecturing and tutorial space respectively.) However, it is difficult to quantify the potential benefit from the extra room. Despite the issue often being raised by practitioners, to the best of our knowledge, it seems that it has not been yet been addressed in the literature, and this work aims to start to fill that gap.

In this abstract, we apply our existing machinery towards quantifying the benefit of the partitionable room. We work in terms of the measures of Utilisation, U and specifically in terms of the critical value as measured by the procedures detailed in Beyrouthy et al (2007c). Notice that we use the term "partitioning" to avoid confusion with the quite different idea of "splitting," or "sectioning"; the latter are concerned with dividing large groups of students into smaller groups so that they fit within the available rooms (see, for example, Beyrouthy et al (2007b); Murray and Müller (2007)). It is quite possible that room partitioning and group splitting should be performed simultaneously.

2 Methods

The operation of opening or closing a room divider might well be quite time-consuming. Hence, and for simplicity here, we will assume that it is performed only twice per week, and then only at day boundaries as more setup time will be available. Therefore, the room is partitioned for an integral number of days. For simplicity here, we also assume that there is only one movable partition per room; rooms can be partitioned into two smaller rooms.

In our initial simplified model there are no constraints affected by the permutation of days, so it does not matter which particular days the room is partitioned, but only their number. Hence, the only parameter that is needed here is:

$$D = \text{`number of days the room is partitioned and functions as two rooms'} \in \{0,...,5\}$$

Effectively, we can think of the partition being open at the start of the work week, and (possibly) closed after D days of being open. The choice $D = 0$ corresponds to the room never being partitioned, and hence the partition never used. The choice $D = 5$ corresponds to the room always being partitioned, and so a cheaper fixed wall could have been used instead. These two choices thus correspond to a movable divider never being used. Hence the issue is whether $D \in \{1,\ldots,4\}$ leads to better results than $D \in \{0,5\}$ and if so how much better?

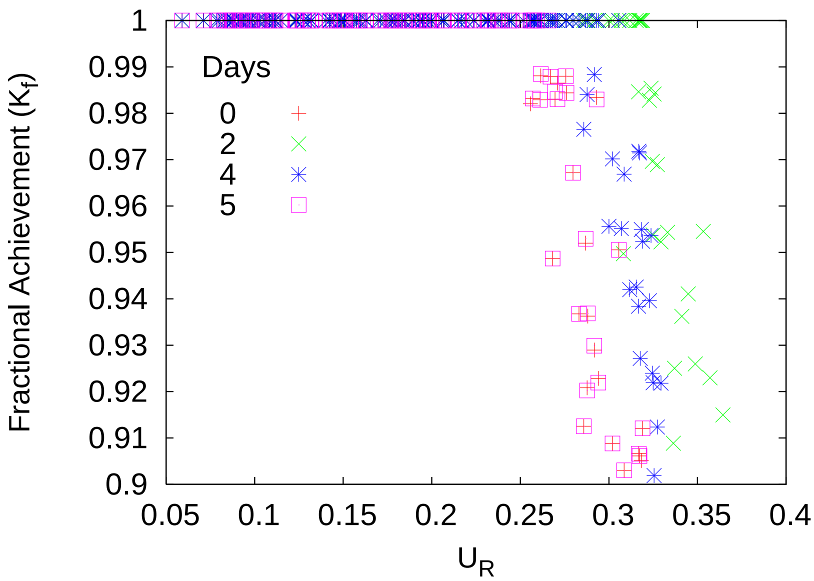
We evaluate the critical utilisation in the manner of Beyrouthy et al (2007c). We produce an "achievement curve" that gives the achievable utilisation, U_A, as a function of the requested utilisation, U_R. The success ratio, $K_f = U_A/U_R$, is typically reliably 100% when all the events can be accommodated; but drops rapidly above the critical utilisation.

There are two cases to consider:

- **Preset-D**: On solving each sample of events the value of D is fixed. This would correspond to the case in which there is no flexibility in the opening times of the partition. E.g. the needed labour is only available on Tuesday afternoon.
- **Dynamic-D**: The value of D can be selected so as to best match the selected set of events. This must give utilisation at least as large as the preset case, and could possibly increase utilisation. For example, the set of events might have too many large events for a timetable to exist with $D = 2$, but will have a timetable with $D = 3$.

Notice that a partition of a room can give, at best, the benefit of a new room. Thus if the number of rooms is already large then the effect of partitioning a single room is likely to be small. Furthermore, intuitively, the need for a partition is most likely to be large when the room sizes are not a good match for the events. This is also more likely to be true when the number of rooms is small.

Fig. 1 Effect of days partitioned, D, on the achievement curves.



We use a straightforward integer programming encoding in order to solver the associated timetabling problem for each sample of events. Lack of space precludes giving details. However, we do note that for simplicity, currently, for the case of 'dynamic-D' the value of D is not coded within the IP model, but rather each value of D is solved separately, and the best D in terms of utilisation is used.

3 Results

As 'proof-of-concept', we consider a simple small example, with just 10 rooms ranging in size from 45 to 310 seats, and with 15 time-slots per week. The data is based on that used for Beyrouthy et al (2007c), and uses artificially generated enrollments, see Beyrouthy (2008); Beyrouthy et al (2008b). Furthermore, 3 rooms are allowed to be partitioned, and for simplicity we assume that they are partitioned for the same D days per week. The associated achievement curves are given in Figure 1. We see, in this example, that with preset-D the value $D = 2$ with critical utilisation of 33% is better than having either the room never partitioned, $D = 0$ with 28%, or always partitioned, $D = 5$ also with 28%. In this particular case, allowing D to be dynamic did not improve upon the results with preset D.

4 Conclusion

We have presented evidence to support the hypothesis that, in some circumstances, having partitionable rooms can lead to an increase in the critical utilisation. Most importantly, we give methods that allow this increase to be estimated. The intended usage is that the space planner would be then be able to use this information for a cost-benefit analysis of proposed room partitions. Thus, contributing towards putting the space planning process on a sounder economic footing.

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