# Schedule Pattern: an Innovative Approach to Structuring Time in Secondary Schools Scheduling

Baiyun Tao, Rick Dwyer

*Follett Software Company/X2 Development Corporation, Hingham, MA, USA*

btao@FollettSoftware.com

rdwyer@FollettSoftware.com

## 1 Introduction

This extended abstract describes the structure of time used by secondary schools in the United States, three common scheduling models each utilizing time differently, and an innovative approach using schedule patterns to efficiently and flexibly schedule classes into a master schedule. The content of this extended abstract is based on over 20 years of practical experience scheduling secondary schools in the United States. During that time the authors have built thousands of high school and middle school schedules using various versions of timetabling software we created.

The school year in a typical secondary school in the United States is comprised of 180 days. Each school day consists of about 5½ - 6 hours of instruction resulting in approximately 1000 hours of instructional time per student per school year. Partitioning instructional time between the various curriculum content areas (math, science, social studies, language, art, music, technology, etc.) is a key challenge. The structure of time in the school schedule provides the framework for how this partition is accomplished.

In section 2 we define three fundamental parameters that govern the structure of time in a secondary school schedule: terms per year (TPY), days per cycle (DPC), and periods per day (PPD). The value of these parameters determines the kind of schedules possible.

In section 3 we describe three common scheduling models and some of their variations. Each model makes specific choices regarding the values of TPY, DPC, and PPD which impact not only the student and teacher experience but the challenges involved in scheduling the school.

In section 4 we describe schedule patterns, an innovative approach to grouping time slots into valid schedule instances. By combining schedule patterns into pattern sets and assigning pattern sets to courses we can significantly reduce the work involved in scheduling each course.

In section 5 we describe schedule rotations. A schedule rotation remaps time slots from one schedule matrix (DPC x PPD) to another schedule matrix with the same dimensions or one with different dimensions. Rotations are applied post schedule build. They allow a user to schedule their school using simple, uniform patterns and then transform it into a schedule with more complex varied patterns.

# 2 Structure of time in secondary school schedules

In everyday life time is organized around clocks and calendars. The calendar splits up the year into months, weeks, and days while the clock splits up the day into hours, minutes, and seconds. A week is a block of seven days that repeats throughout the year. These structures provide a universal way to talk about time and schedule our lives. In the same way secondary schools in the United States use analogous time structures to meet their scheduling needs.

## 2.1 School Year

The school year consists of 180 school days. A school year typically starts in August or September and ends in May or June. The specific start and end dates depend on state requirements as well as the number and duration of school vacations and holidays.

### 2.2 Schedule Term

A schedule term is a portion of a school year. Common schedule terms are full year (180 days), semester (90 days each), and quarter (45 days each) (see Fig.1.1). Schools can define as many different schedule terms as the schedule requires.

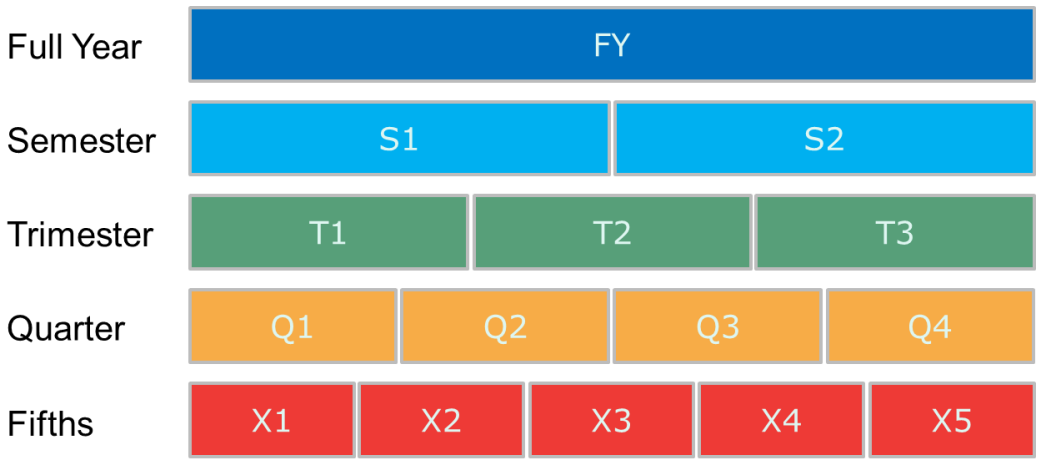


**Fig 1.1** Typical scheduling terms

Typically a course is scheduled over a single schedule term. But courses can be schedule over multiple schedule terms. For example an art course could be scheduled over two trimesters (120 days or 2/3 of the school year) (see Fig 1.2).

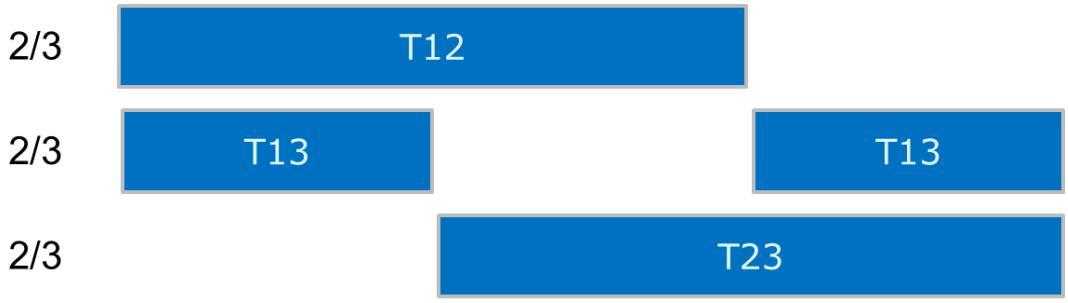


**Fig 1.2** Combine schedule terms consecutively and non-consecutively

### 2.3 Schedule Cycle

The schedule cycle is analogous to a week on a standard calendar. It is a fixed block of days that repeats throughout the school year. The school defines the number of days in the schedule cycle. Most schools do not use a 5 day cycle and

therefore the days in the schedule cycle do not correspond to the days of the week. An even number of days such as a 6 day cycle is more common and allows multiple sections of a partial cycle course to be scheduled in the same period on alternate days.

### 2.4 Day

The schedule day is simply a day in session. Public schools in the United States are only in session during the week – they do not meet on Saturday or Sunday.

### 2.5 Period

The school day is broken up into periods. Each day has the same number of periods and each period has the same duration. This uniformity allows courses to be scheduled during any period of the day. Typically a bell rings to mark the start and end of each period. Between each period students usually have 3-5 minutes get to their next class.

The structure of a schedule is therefore defined by three fundamental parameters: the number of term per year (TPY), the number of days per cycle (DPC) and the number of periods per day (PPD).

The number of days per cycle and the number of periods per day (DPC x PPD) defines a simple schedule matrix.

The shape of the schedule matrix ultimately has the biggest impact on the day-to-day experience of students and teachers in a schedule. It governs the amount of time a student spends in each course during a day and the variety of courses encountered during the cycle.

# 3 Three Common Scheduling Models

In this section we look at three common scheduling models: traditional, block, and hybrid.

## 3.1 Traditional Schedule

The most common traditional secondary school schedule has 7 periods per day and 6 days per cycle. Traditional schedules usually vary between 6 – 8 periods per day – the more periods the shorter the duration of each period.

Academic classes (English, math, science, and social studies) in a traditional schedule usually run for a single period every day for the full school year. Non-academic classes (art, music, or physical education) often receive less instructional time. Changing the instructional time a course is schedule is accomplished by reducing the number of days in the cycle or the number of terms per year the course is scheduled. Partial cycle or partial year courses are common in a traditional schedule. For example, physical education could be scheduled every other day rather than every day and may only run a semester rather than a full year. Typically a traditional schedule includes both semester and quarterly courses.

In a traditional (7 x 6) schedule, students take 7 or more classes in the same term. Teachers teach for 5 periods per day and usually have at least one period free for planning the other period could be scheduled as a duty.

## 3.2 Block Schedule

The most common block schedule has 4 periods per day and 1 day per cycle. This is called a 4x4 block schedule [1,2]. Each course meets 90 minutes per day for a semester.

A popular variation on the 4x4 block schedule is the A/B block schedule. The A/B block schedule also has 4 periods per day but each course meets every other day for the entire school year rather than every day for a semester.

With a smaller number of periods per day the block schedule allows extended learning time each day in each class. Students and teachers also have fewer classes meeting on each day.

### 3.3 Hybrid Schedule

A hybrid schedule is one which combines the traditional schedule and the block schedule. A common hybrid schedule has 8 periods per day and 2 days per cycle. Courses in a hybrid schedule are usually scheduled in 1 period (traditional) or in 2 consecutive periods (block).

## 4 Schedule Patterns

The master schedule builder schedules sections of courses. A course defines the curriculum content while a section defines an instance of that content in the schedule. For example a high school schedule will typically include a geometry course. If 100 students request geometry, multiple sections of geometry will be scheduled. A section represents a specific instance of the course scheduled at a particular time, in a particular room, by a particular teacher.

Schedule patterns represent the valid ways a particular course such as geometry can be scheduled and provide a visual representation of the shape of a course in the schedule. The following are common schedule patterns in a traditional 6 day schedule (1 period every day, 2 periods every day, 1 period every other day, and 1 period on 4 days and 2 periods on 2 days).

The defining attributes of a schedule pattern are the following:

- Days: number of days scheduled in the cycle
- Periods: number of periods scheduled during the day

- Terms: portion of the school year the pattern covers. By default a schedule pattern is term agnostic so that it can be used in conjunction with any schedule term to represent different time slots cross the school year. (see Fig.2.1) It can also be term aware and specifies the particular terms covered (see Fig.2.2).
- Shape: the distribution pattern of time slots (see Fig.2.1).

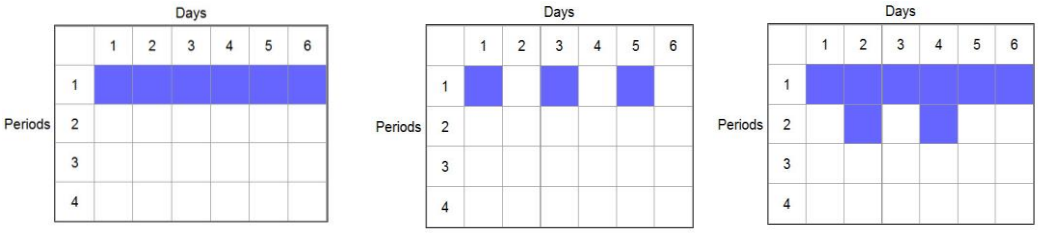


**Fig 2.1** Term-agnostic schedule patterns: every day, every other day and lab

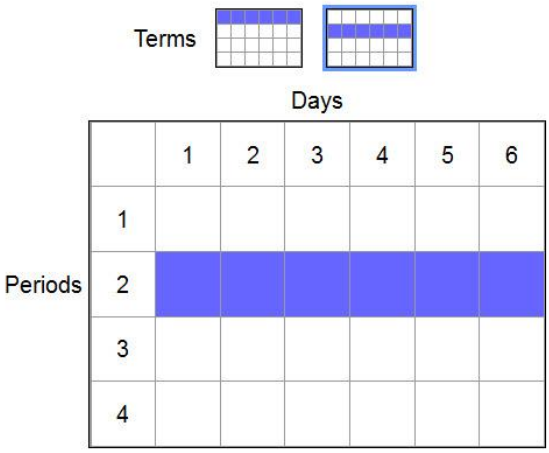


**Fig 2.2** Term-aware schedule pattern: period 1 on S1 Period 2 on S2 (focus on S2)

Schedule patterns are grouped together as pattern sets. Each course in the schedule is assigned a pattern set containing the valid schedule patterns for that course. Courses scheduled in the same way typically share the same pattern set. However a schedule patterns can be used by multiple pattern sets. So a course that should only be scheduled in the morning could be associated with a pattern set containing only morning schedule patterns.

Schedule patterns allow the system to efficiently and effectively schedule course sections into valid time slots. For example, there are 20 possible day combinations

for a partial cycle course scheduled on 3 days in a 6 day cycle (in a single period). In reality, however, only 2 of the 20 possible day combinations are typically valid – the odd and even day combinations (1,3,5) and (2,4,6).

Schedule patterns allow the user to visually "paint" only the valid time slots available for each course. This can significantly reduce the amount of work the schedule builder expends in scheduling each course.

## 5 Schedule Rotations

Another common scheduling practice among secondary schools in the United States, especially in middle schools, is a rotated schedule [3]. A schedule rotation remaps time slots from one schedule matrix (DPC x PPD) to another schedule matrix with the same dimensions or one with different dimensions. Rotations allow users to schedule their schools using simple, uniform patterns and then transform it into a schedule with more complex varied patterns post build.

In a flat schedule a course scheduled during the first period of the day is schedule in the first period of the day on each day of the cycle. A simple rotation can vary the period each class is scheduled across the different days in the schedule. This allows a student to learn math at different times of the day on different days in the schedule.

Rotations also allow schools to change the structure of a schedule post build. A common scheduling rotation swaps the periods per day and the days per cycle. For example a 7 x 5 schedule could become a 5 x 7 schedule. In the old schedule an every-day class met for 45 minutes. In the new schedule the same every-day class now only meets 5 days out of 7 but for 63 minutes each meeting. (See Fig.3.1)

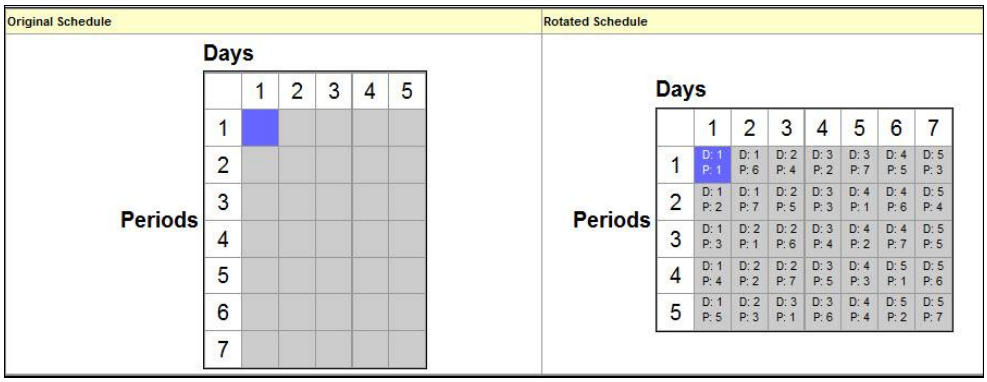


**Fig.3.1** Define a rotation: from a 5-day 7-period to a 7-day 5-period schedule

To handle such flexible scheduling modes, simple flat schedule patterns are created and used to build the master schedule. When the scheduling is finished the schedule is transformed into more complex patterns through the rotation. Sections are then being rotated based on the rotation definition. An example of simple flat pattern and the more complex rotated patterns is shown in Fig.3.2.

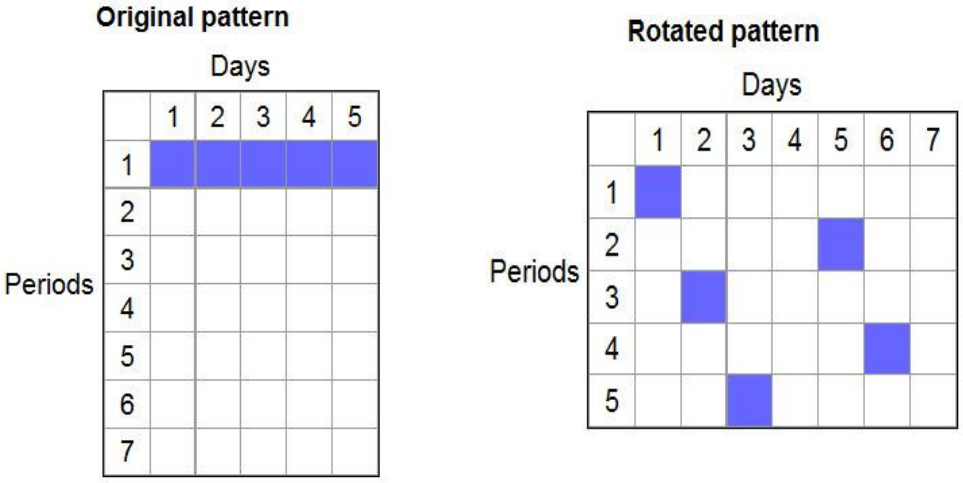


**Fig.3.2** Original and rotated schedule patterns

# 6 Conclusions

In the United States, secondary schools structure time in a variety of different ways resulting in very different types of schedules. By allowing schools to define the number of periods per day, the number of days per cycle, and the number of terms per year, they have the flexibility to create a broad spectrum of different schedules each meeting variety of different scheduling needs. We looked at three

scheduling models and some variations on these in this extended abstract: the traditional schedule, the block schedules and the hybrid schedules.

The approach reported in this paper is implemented in Aspen master schedule builder, a web-based automate master schedule builder that has been used by many secondary schools in United States and abroad.

## References

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