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Bullet TimeTabler Education – System demonstration

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1 Introduction

The problem of creating timetables for Educational Institutions is typically defined as the scheduling of a set of lessons involving teachers and students, on a set of classrooms, in certain time slots, considering a number of constraints (Schaerf 1999; Bonutti et al. 2012).

Throughout an academic year, in every Educational Institution, a considerable number of days and human resources are spent trying to find, manually, a solution that respects all the existing rules (a feasible solution) and that, at the same time, can meet the expectations of all participants (a quality solution).

Due to its combinatorial nature and associated complexity, this is one of the most studied problems by the scientific community and by the Operational Research area in particular (Schaerf 1999; Murray et al. 2007).

This paper presents the product Bullet TimeTabler Education (BTTE), an automatic and optimized generator of timetables. This software application is the result of the work carried out by Bullet Solutions since 2005. BTTE has been updated and improved over the years with the contributions from almost all the Portuguese Higher

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Education Schools (Universities and Polytechnic Institutes), as well as some foreign institutions.

The BTTE software is successfully used in more than half of the Portuguese Higher Education Schools, including the 10 major ones.

2 Bullet TimeTabler Education

2.1 Application suite

The Application Suite consists of software modules that exchange data with each other. In this paper only two of them are mentioned: BTTE – automated generation of timetables; and Bullet Calendar (BC) – edition of timetables and management of events and resources.

BTTE is the intelligent centrepiece of the system, the calculation engine and therefore it is the main focus of this paper.

Figure 1 shows the application diagram.

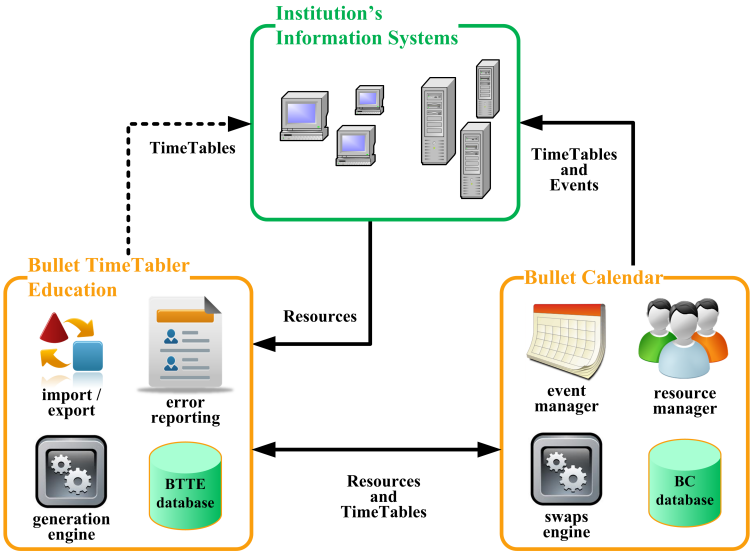

Fig. 1 Application diagram

BTTE is an innovative software application that automatically generates timetables for Higher Education Institutions. It combines and optimizes several objectives in accordance with the interests of the Institution, optimizing schedules for teachers and students as well as the classrooms' occupation, among other goals.

BC is a module that allows an efficient daily management of all activities and resources in an Educational Institution, through a decision support tool. This application can work independently or integrated with BTTE.

Figure 2 shows the Application Suite's workflow.

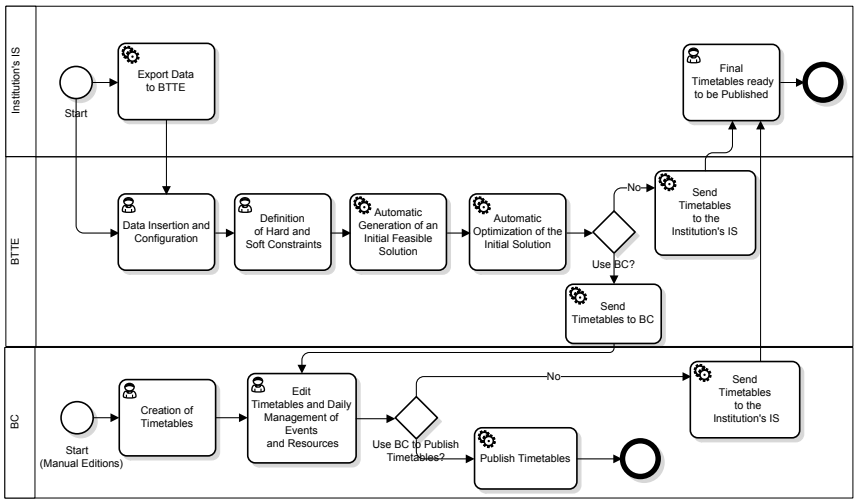

Fig. 2 Application Suite's workflow

2.2 Model definition

BTTE does not schedule individual students, only groups. The assignment of students to groups occurs in a separate process, where the students apply for the existing timetables, choosing the most suitable ones. In some cases, the Institution itself defines the association of students to the groups. The conflicts are based on the curricula structure and the Portuguese situation can be included in the Curriculum-Based Course Timetabling problem (Bonutti et al. 2012).

A complete analysis of the proposed model, the fundamental concepts and the constraints (hard and soft) involved in the problem, can be found in our previous work (Fernandes et al. 2013).

2.3 Building the timetable

A sequential heuristic is used to build an initial timetable from an empty timesheet. Once the initial solution to the problem is found (the starting point), the optimization phase is initiated; based on appropriate methods, better solutions are progressively searched. In BTTE, the search for new solutions is based on neighbourhood structures. Besides the different construction methods of neighbourhoods, the implemented optimization algorithms go through three major phases: normal, intensification and diversification. Each of these phases is specified to achieve a particular purpose, and their joint operation is the key to a final optimized outcome.

The heuristics were fully developed from scratch, adapted to the existing problem and created model.

Figure 3 shows a screenshot of the optimization phase.

A complete description of the proposed algorithms (construction heuristics and improvement heuristics) can be found in our previous work (Fernandes et al. 2013).

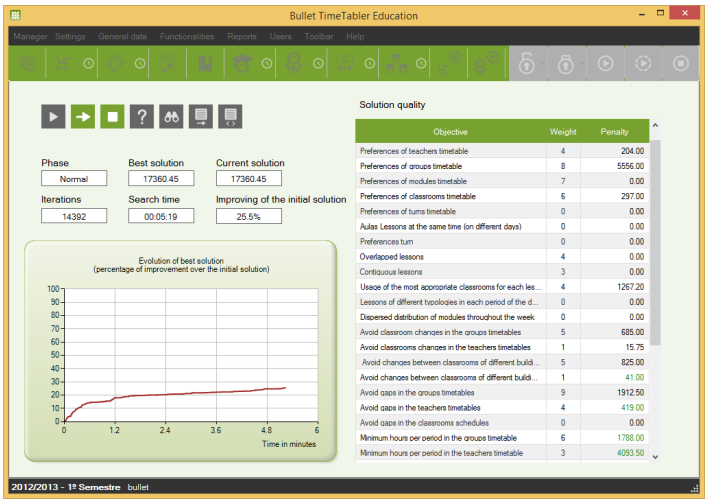

Fig. 3 BTTE – Optimization phase

2.4 Editing the timetable

When the automatic generation stage ends, BTTE sends the timetables to BC, where the user can edit timetables and manage events and resources.

BC is a module that is used continually, since it can easily respond to all the changes that inevitably occur during the year. If, at any time, profound changes are needed, the user can get back to BTTE and generate a complete solution from scratch, or just generate the affected events keeping the rest of the solution untouched in BC.

Figure 4 shows a screenshot of a swap operation using BC.

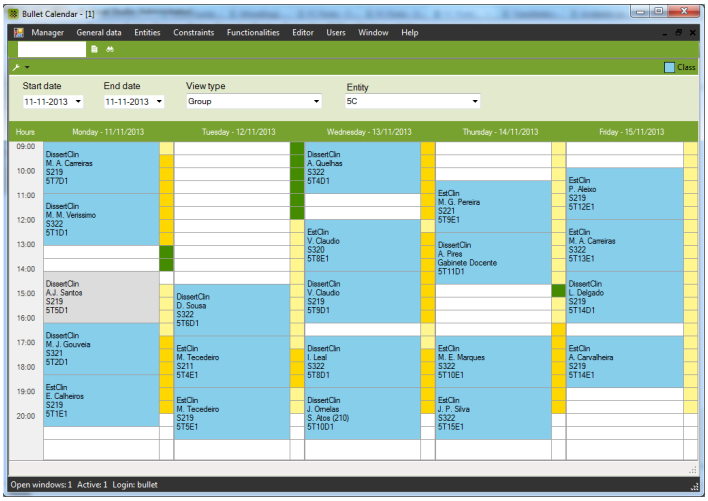

Fig. 4 BC – Swap operation

Some of the main features of BC are: totally flexible agenda, with easy configuration of time slots and working hours; real-time information about the occupation of the Institution's resources; quick editing of timetables with several views; quick analysis of all the possibilities and limitations of swapping a specific event; total flexibility for changing any resource associated with any event; fast Web publishing of timetables; exporting and printing schedules and dozens of different reports.

3 Conclusions

The main conclusions that can be extracted from the work developed are closely linked with the commercial success of the BTTE application.

In our previous work (Fernandes et al. 2013), twenty real cases of Portuguese institutions, users of BTTE, were analysed. The fact that results with good quality, with savings of 85% on the time spent in the process, were obtained in all analysed cases, leads to the conclusion that the algorithms used in the BTTE application have a considerable level of robustness and ease of adaptation to the quite diverse real scenarios that were used for their evaluation.

Recently, after testing different parametrisation of the heuristics and with the improvement of the data structures that support the product, very interesting results were obtained. In some cases, optimized timetables were produced 10 times faster when compared with the results presented in Fernandes et al. (2013). These results will be published in the short term.

The implementation and use of the BTTE application allowed significant improvements in processes directly and indirectly related with the creation of timetables, resulting in additional productivity gains.

It was possible to observe the organization and centralization of information in most of the institutions and the elimination of redundant information. An increase in speed and efficiency in the workflow and in the information flow was also observed.

There is a better control of the process by top management, particularly the real needs of the distribution of teaching service. Scenarios where the generation of timetables was far from top management and dispersed by various departments, were common in the past, resulting in the recruitment of resources that later on proved to be unnecessary. There have been considerable savings in hiring teachers, after using the BTTE application.

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