Dynamic Curriculum Structuring - The Foundation for Timetable Management in Faculty Information System

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Abstract- **The timetable design for complex faculties or universities is the challenging problem that is almost always opened while designing University Information System. Generally speaking, timetable planning is an activity of assigning arbitrary element of interest (object) to time and space facet according to the predefined constraints that have to be simultaneously satisfied. It is well known resource allocation problem with combinatorial nature that is usually classified as NP-complete (Non-deterministic Turing Machine) problem. One of the most challenging constraints is the Curriculum Structure with dynamic structuring abilities. In this article we present Dynamic Curriculum Structuring Support Model that may serve as a foundation for timetable development. It is implemented as a constraints formulation layer in Faculty of Technical Sciences Novi Sad Information System component that supports the timetable management.**

Key words: Curriculum Structuring, Constraints Formulation, NP-complete Problems; Model Driven Software Engineering; Service Oriented Architecture; University Information System, Timetable Management

I. INTRODUCTION

The general term university timetabling typically refers to both university course and exam timetabling. As discussed in [1] both problems are different in nature. In examination timetabling one of the goals is to spread, to the best possible extent, the different exams for each individual student, while in course timetabling the students want an as compact timetable as possible. Recurring timetables (weekly, fortnightly, etc.,) are appreciated for course timetabling, while for exam timetabling this is certainly not the case [2]. In this article we have focused on university course timetabling due to its higher level of complexity and the existence of external regulations and roles that have to be satisfied according to the accreditation and quality management principles.

The university course timetabling problem is the process of assigning lectures, which are covered by lecturers and attended by students, into 'room–time' slots, taking into account hard and soft constraints. Hard constraints cannot be violated, since that would make the solution infeasible. Neither students nor lecturers, for example, can physically be in two different places at the same time, thereby avoiding so called event-clashes is essential [3]. In contrast to hard constraints, violations of soft constraints are possible but if there are none, the quality of the solution is experienced as 'better'. An example of a soft constraint can be to avoid time laps between lectures on the same day, thereby smoothing group and individual work assessment. Constraint-based reasoning is a problem-solving technique that combines logic programming and constraint-solving technique based on an arc-consistency algorithm [4].

Timetable planning (TTP) is an activity of assigning subjects to time and space such that all constraints are satisfied simultaneously. Currently, most of the timetabling systems in educational sectors are not fully automated and require substantial assistance from human experts. The main reasons behind this problem are the combinatorial and dynamic nature of the problem. TTP is basically a resource allocation problem and can be treated as a constraint satisfaction problem (CSP). It is well known that resource allocation problems are combinatorial problems that have been classified as NP-complete problems (Non-deterministic Turing Machine). Most of the NP-complete problems are hard to be solved optimally and efficiently because of the enormous size of search space and they grow explosively with the number of variables [5]. In order to solve this problem, we need an efficient algorithm to search for a feasible and best solution [4]. In [6] paper, the authors present an investigation into using fuzzy methodologies to guide the construction of high quality feasible examination timetabling solutions. The provision of automated solutions to the examination timetabling problem is achieved through a combination of construction and improvement. The enhancement of solutions through the use of techniques such as met-heuristics is, in some cases, dependent on the quality of the solution obtained during the construction process. With a few notable exceptions, recent research has concentrated on the improvement of solutions as opposed to focusing on investigating the 'best' approaches to the construction phase.

According to [7] Integer programming has always been an alternative for formulating combinatorial problems. However, the effort required for modeling complicated operational rules, as well as the computational difficulties that result from the

size of real problems have discouraged researchers and made them turn their interest to other approaches. In [7], a two-stage relaxation procedure that solves efficiently the integer programming formulation of a university timetabling problem is presented. The relaxation is performed in the first stage and concerns the constraints that warrantee consecutiveness in multi-period sessions of certain courses. These constraints, which are computationally heavier than the others, are recovered during the second stage and a number of sub-problems, one for each day of the week, are solved for local optima. Comparing to a solution approach that solves the problem in a single stage, computation time was significantly reduced without any loss in quality for the resulting timetables [7].

A. The Accreditation of Study Programs Framework

With the proscribed accreditation and licensing constraints the high education institutions in Serbia face two common problems:

- the mandatory static structure of study programs that have to be "frozen" in order to gain the compliance with strictly defined accreditation standards constraints; and
- the dynamic nature of operational aspects that drives sustainability of study programs when they expose themselves to the educational market.

Serbia has joined the Bologna Process in 2003 and thus initiated a gradual reform process, which received its legal support in 2005 by the adoption of a new Law on Higher Education. This law formally introduced the European Credit Transfer System, three-cycle system of study and diploma supplement.

From 2007/08 all new students study under the new reformed study programs at all higher education institutions. All types of higher education institutions in Serbia can organize and conduct study programs and issue first and second cycle degree certificates (universities–academic and professional), but only universities can implement the third cycle education. The National council of higher education, at its session of 20 October 2006 approved the following [8]:

- Rules and Regulations on self-assessment and quality review of higher education institutions, the integral parts of which are the self-assessment standards and quality evaluation of higher education institutions;
- Rules and Regulations of external quality control of higher education institutions and procedure for external quality control in the higher education institutions, the integral part of which are the standards for external quality control in the higher education institutions;
- Rules and Regulations on accreditation standards and procedures of higher education institutions and study programs, the integral parts of which are 1) accreditation standards of higher education institutions; 2) study program accreditation of the first and second tiers of higher education; and 3) doctoral study program accreditation.

Higher education institutions have a legal obligation to develop internal quality assurance systems. Implementation of the standards for internal quality assurance is in the first place the responsibility of the institutions. Internal quality assurance is one of the themes in the accreditation frameworks. According to [9], the database of the Ministry of Education and Science (www.mpn.gov.rs) and the database of CAQA (www.kapk.org), there are 189 recognized higher education institutions in Serbia: 13 of them are universities, 65 higher education colleges of professional career studies and 6 higher education colleges of academic studies. In addition to this, there are 109 faculties and academies of arts which represent parts of universities, but are, at the same time, legally recognized as separate and independent legal entities.

Faculty of Technical Sciences, at University of Novi Sad, is the largest single faculty in south east Europe. The Faculty runs 87 study programs that have received the accreditation at all three study levels: bachelor and bachelor professional; master academic, specialist academic and specialist professional; and PhD academic (27 bachelor; 3 bachelor professional; 31 master academic; 7 specialist academic; 3 specialist professional; and 16 PhD academic [10]).

B. The Operationaity of Stydy Programmes Framework

The operational support to study programs implementation and management in real environment demands the adequate Information and Communication infrastructure support. At Faculty of Technical Sciences we have developed the comprehensive computer based cooperative framework that aids the study programs structuring, accreditation documentation management and generation, internal and external quality control support and the operational support for study programs management on academic year basis. It is integrated in Faculty Integral Information System.

Considering the related work analysis in this article we start from a conservation principle that is usually applicable for stabile university institutions. Under stabile university institution we mean the institutions that have reached the equilibrium concerning the student's population and the number of study programs offered to students each academic year.

In such a case timetable generation process may use the referent timetable model and adjust it according to particular changes in running study programs. The referent timetable may be prepared once, by any mean of creation, and stored in the referent data base for the reusability purposes.

II. THE INFRASTRUCTURE MODEL - SOLLUTION DOMAIN

The dynamic changes of the study programs have to be supported through effective service oriented architecture in

order to prepare the delta version of any particular study program that is planned for the next coming education block in current academic year. In Figure 1 there is a simplified infrastructure diagram of the proposed and implemented supporting Information System architecture presented. There are two complementary architecture areas implemented. One of them supports the Accreditation Version of any particular study program management (Accreditation) while another supports the Realization (Realization) of the same study programs. The Comparison Management service port is reserved for future development of set of services that enable real-time comparison of study programs whose models are resident either in Accreditation Programs Data Base (Accreditation Programs DB) or Realization of Study Programs Data Base (Realization Programs DB). The stakeholder support is implemented through Web Service Portal (Implements Service Oriented Architecture) and Client Support Layer (Implements Client-Server Architecture support for Accreditation (AccClient) and Realization (ReClient) management).

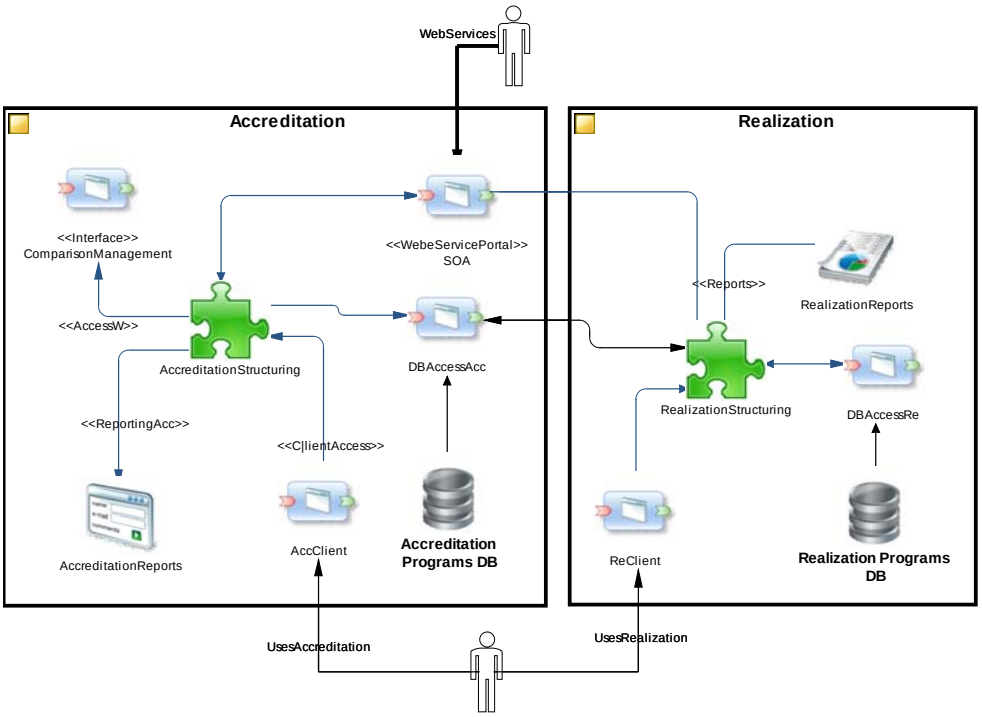

Figure 1 Simplified Infrastructure Diagram of IS services

In engineering, models are usually considered as the means that help to overcome the complexity of real-world problems. In [11] the author purposes the Multi-Domain Systems Engineering (MDSE) that inherits both: The Model Driven Architecture (MDA) and The Domain Specific Modeling (DSM) approaches. The DSM, being a top-down and vertical approach, instead of trying to create a high abstraction level ”interfaces” to the implementation platform, gives domain experts the freedom to use platform independent structures and logic that are specific to the targeted application domain. While Model Driven Architecture (MDA) emphasizes the importance of a single and universal modeling language foundation, proponents of DSM argue that flexibility and ease of use, concerning domain experts, is much more important than sticking to a single formalism. Designing something requires the ultimate understanding of what relevant stakeholders want to accomplish through the concrete solutions usage. The sustainable solution usually emerges when: the expectations, support, and the real behavior of the created artifacts are compliant or suitably well aligned.

III. THE DATA BASE SCHEMA MODEL

The Model Driven Software Development (MDSD) is the implementation practice at Faculty of Technical Sciences Development Team. The state of the art and the perspectives considering MDSD are elaborated in [12] and are the primary applied paradigm in automatic software generation that is traditionally supported from early 1990 up to now. The architectural aspects of Service Oriented Approach to Information System Utilization usually concentrate on so called Blackboard architecture. The essential part of it is a repository that is usually supported by some sort of Data Base Management System. The complete service layer described in this article is based on Data Base Schema Model and The Code Generation Tool. In Figures 2 and 3 there are relevant segments of the repository conceptual models presented.

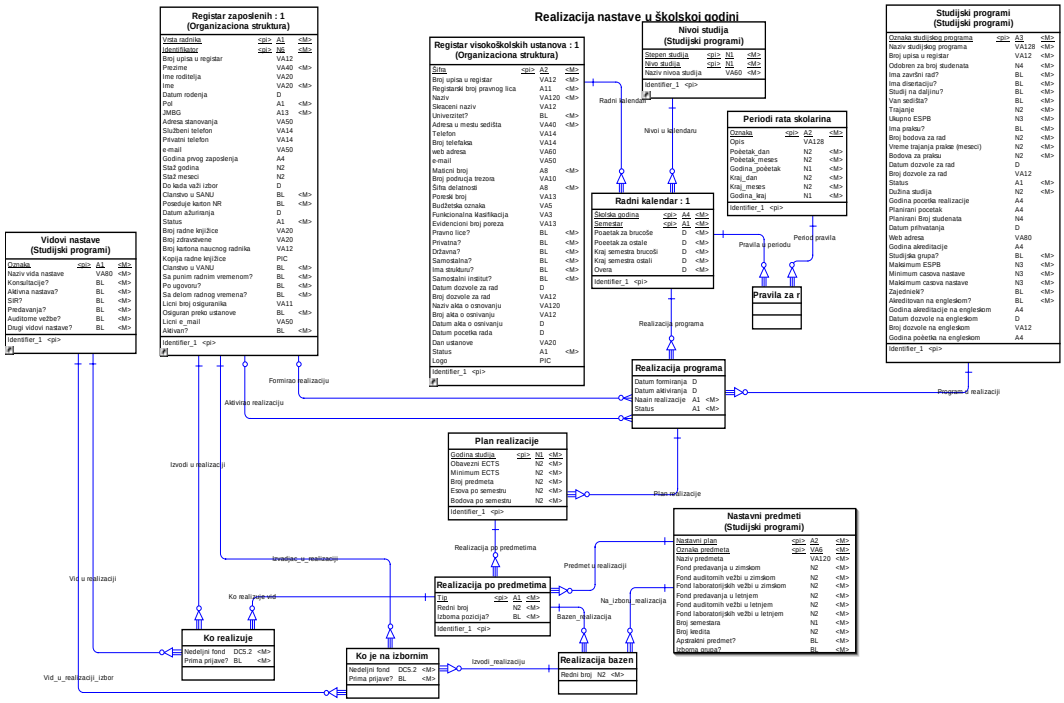

Figure 2. The Part of realization Schema Model

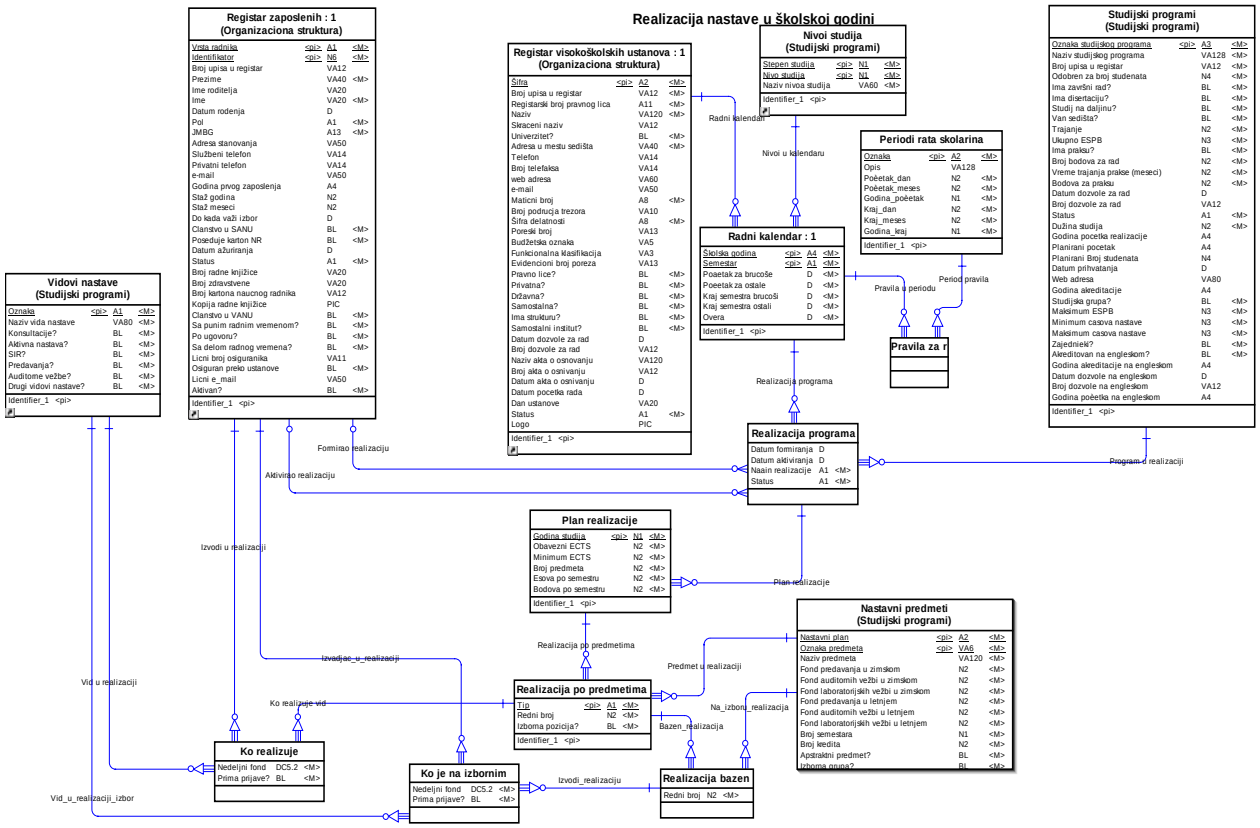

Figure 3 The Academic Year Realization Subschema Model

The detailed elaboration of entities is out the scope of this article.

IV. SERVICES IMPLEMENTATION

The Service Layer infrastructure supporting web-service portal supports several roles that differenciate the acess rights of relevant stakeholders to Accreditation and Realization models of study programs. Tupycal roles are: the head of the chare (that is responsible for people allocation), the study program manager (that is responsible for structuring the study programs from the accreditation and the realization aspects), and the lecturing stuff (teaching assistants and professors that are responsible for operativ activities). In Fig. 4, 5, and 6 there are service portal screen shots for selected situations presented.

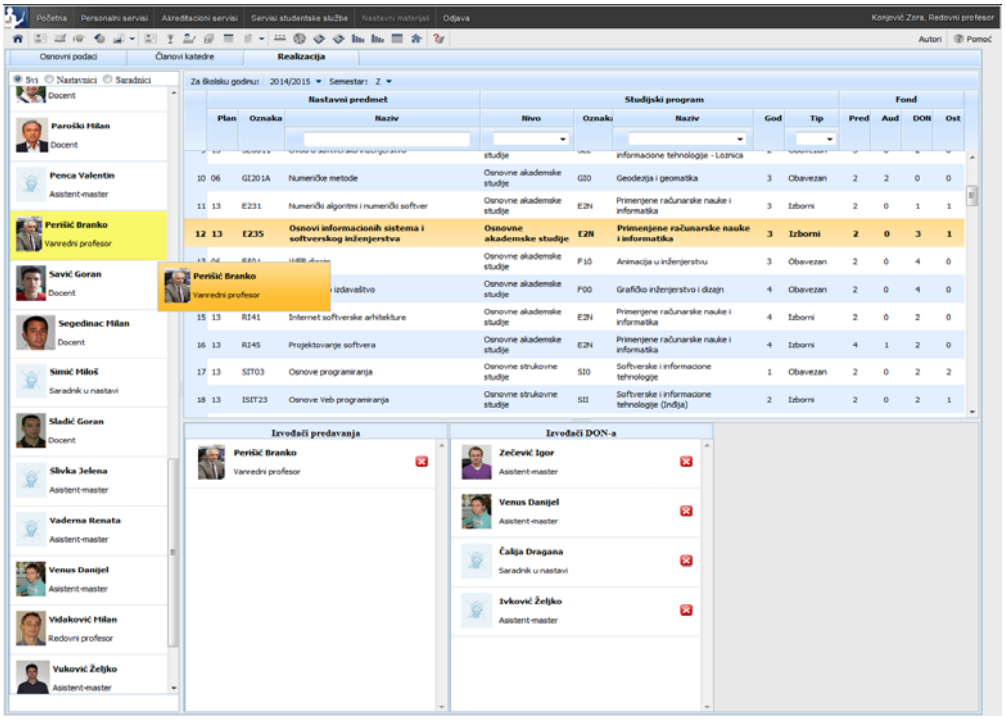

Figure 4 Head of the Chare Lecturers Assignment

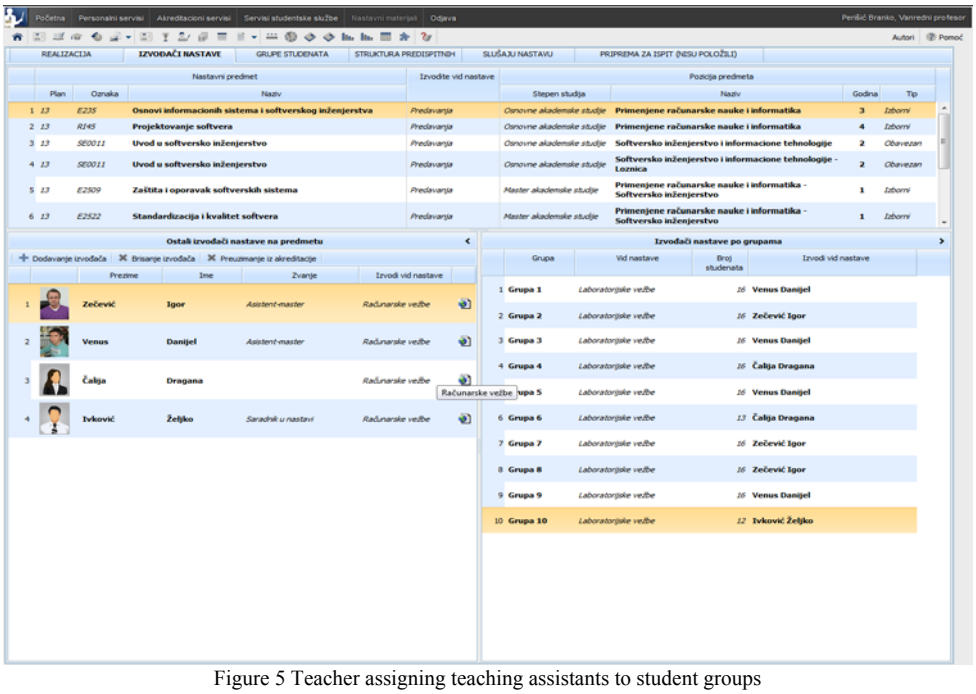

Figure 5 Teacher assigning teaching assistants to student groups

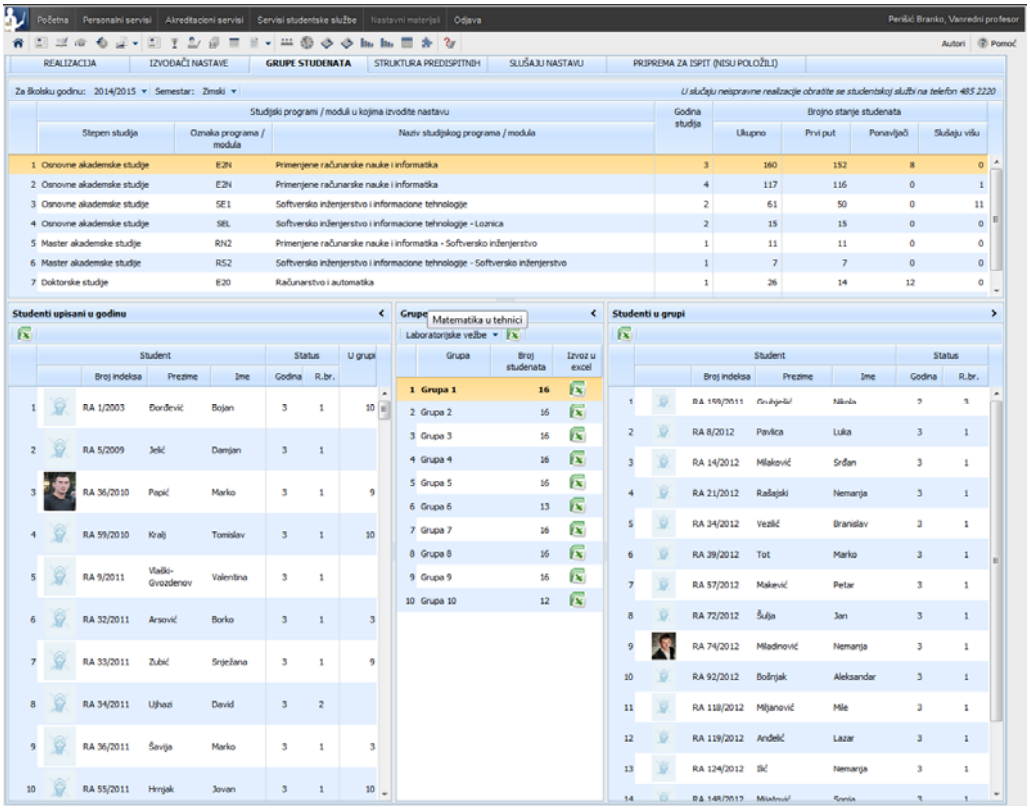

Figure 6 Teacher accessing the students data relevant for the operational activities

V. CONCLUSION AND DIRECTIONS OF FURTHER RESEARSH

The timetable design for complex faculties or universities is the challenging problem that is almost always opened while designing University Information System. Generally speaking, timetable planning is an activity of assigning arbitrary element of interest (object) to time and space facet according to the predefined constraints that have to be simultaneously satisfied. In this article we have present Dynamic Curriculum Structuring Support services that are used for preparing the foundation for lecturing Timetable development at Faculty of Technical Sciences, University of Novi Sad, Serbia.

The future activities will be directed to refining the designed services in order to support the complete set of services that are defined according to the particular stakeholder's mental model.

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