Exam System

Marek Kvet, Martin Forgáč, Erik Kalina
University of Žilina
Žilina, Slovakia
Marek.Kvet@fri.uniza.sk

Abstract—Nowadays education requires modern approaches. For effective teaching, teachers need effective tools which help them lead education process while they do not have to waste time by administration. By using information system where all of administration processes are grouped together, teacher can save valuable time which can be invested into making higher quality teaching. As well as teachers, students using information system are relieved of carrying many not directly necessary stuffs required for learning process. This article analysis new Exam system which is meant to be a system for the subject administration, the administration of lessons, exams, tests. The Exam system should be used by teachers and students at the University of Žilina. In this paper the reader can find information about a concept of the exam system, its functions, and details about them.

I. Introduction

The proposed system is used for examining students during the semester and at the final exam of the subject, for the administration of the subjects, tests for students associated with the questions and the answers connected to them. The system is meant to be the leading system for examining students at the University of Žilina. Currently it is used in two subjects: Database systems and Advanced Database Systems.

The system is created by students during master's degree study. A group of students is chosen every year to participate on the development of the exam system. Students create new functionality, maintain the system, upgrade necessary parts etc. Everything is controlled and is led by the teachers and doctoral students who are assigned to this project.

The advantage of this approach is that the students know which parts of the system they use the most and which parts of the current system make them difficulties to work with, so they can create a solution to the problem and implement it to the system, if the teachers accept the solution, so other students will not have same difficulties in the future.

Another advantage is that the system will be upgraded regularly so it does not grow old and insufficient, but every semester it will have new functionalities and options for the teachers and for students. Because of the modular architecture which is quite robust and highly scalable, there is a possibility to relatively easy extend system for other functionalities, as well as adding new school subjects.

Solution is based on automatic Select statement evaluation and core of the system reflects temporal database principles [2], [3], [4]. Performance is ensured by dynamic indexing [5].

II. Related work

As an important side of modern teaching, computer-aided examination can reduce all kinds of subjective factors during every link to arrange examination more objective, faster and safer [12]. According to Shao King [1], more and more students are rushing into colleges and universities, and it is no doubt a great challenge to them in shortage of education resources and declining trend of the training quality. A few students making seeking no progress, being opportunistic and cheating in examinations, not only affected the performance of authenticity, but also discouraged the learning enthusiasm of majority of students.

Network examination system based on web is usually used in examinee self-testing or network teaching, for example, ATA intellectualized examination service system whose core technologies are DST technique, RET technique, SRAT technique, LAS technique and ZNM technique. This system can imitate application software of real environment and operation process and steps of system software, and avoid the dependence to environment, so that it is totally independent in real execution environment [12].

Some researchers have been investigated in modeling, implementation, and application of automatic computer examination systems (ACES). These systems are based on the question-answer style, which grades a student by asking many questions and scoring the correct answers. In most design of ACES, the questions are proposed apparently in order but always can be answered without order [6]. The main purpose of Catherine Vafeiadou, Pantelis Vasiloudis, Minas Dasygenis [11] project was the development of an integrated system that generates examination papers with random questions about the curriculum of digital circuits' courses. This system consists of a database, a website and a questions' program generator.

According to Zhikao Ren, Minghua Liu, Chen Ye,Xiuying Wang and Chuansheng Wang research [10] the design of paperless examination system may meet the specific requirements of general examination, and can carry out a full, smooth examination process, at the same time this system could have some outstanding characters include of convenience, flexibility, security.

III. Concept

The system is being created to replace current exam system, Moodle. Moodle is a learning platform designed to

provide educators, administrators, and learners with a single robust, secure, and integrated system to create personalized learning environments. [8] Moodle is third-part software so no one from the faculty can add new functionality to it or change some options of the system.

The replacement with the new exam system offers these new options because it is being created inside the Faculty of management science and informatics. The teachers and students

during their work have found many interesting ideas how to improve the exam system but until now it was impossible. Nowadays students who work on the project related to the new exam system can implement new functionalities, so the new system will contain all necessary and optional parts for better usage.

It would be also possible to repair bugs more regularly and to create new functionalities more often because every semester the group of students work on the system so it would be faster than it is in the current system.

IV. System architecture and implementation

The system is implemented using a web application that guarantees functionality on any device. Client side is created by Angular framework based on TypeScript. Application type is Single-Page which means, that page is loaded only once an do not need to be refreshed every time a request is posted. So scipts, styles and HTML is loaded in first approcach of page and subsequently, only requested data are loaded from server. Beacause of this application type, it is easy for using and faster than Multi-Page. A little penalty for using Single-Page is weaker security.

On the server, there is ASP.NET Core apllication controlling and managing all request from client. This apllication runs on .NET Core framework, which provides modern approaches of web applications programming. Also it can run on multiple operation systems such as Microsoft Windows, Linux or MacOS.

For storing data there is database system running on own server. Because of great compatibility with Microsoft products, we use Miscrosoft SQL Server. The work with data in database itself, is done using Entity Framework. This framework is Object-Realational mapping (ORM) tool which simplifies and speeds up process of programming and therefore createing of system. Another big advantage of using ORM is universal using of programmed code for work with data on other types of database systems. A generally lower performance of application using ORM is not a problem for our system as we do not work with a big data and apllication is relatively of small size.

Back-end is built on Multitier architecture which consists of Data layer, Business layer and Rest API. Such separation of layers and responsibilities significantly contributes to and facilitates the way applications are developed and maintained.

Rest API layer is in our multi-tier architecture top layer that the Back-end contains. It is the layer with which the front-end

communicates. This layer consists of four basic parts (Fig. 1). The first part is Services. They take care of the communication between the Rest API and the business layer. The next part is the Controllers. The front-end communicates with them and the functionality itself is made available through them. The third part is Extensions. They have all the extensions that are needed. The last part is Installers. Here are configurations, addition of an auto mapper for mapping objects in database, configuration the authentication and set up the project.
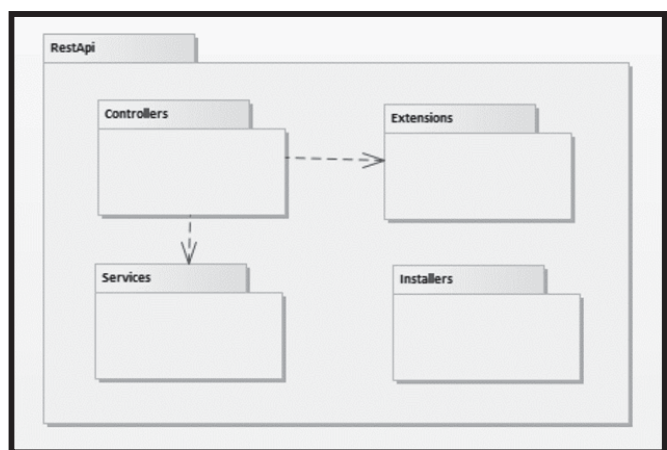

Fig. 1 Package diagram of Rest API Layer

Middle layer contains business logic. This Business layer takes care of the cooperation of Rest API and the data layer. If it is necessary to modify the read or stored data in any way, this happens on this layer. It consists of two basic parts (Fig. 2). They are business managers who perform requests and mappings that map data objects to a business object.
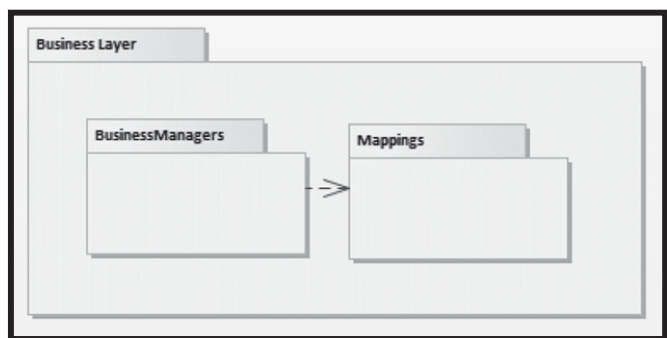

Fig. 2 Package diagram of Business Layer

The layer providing communication between the application and the data source is the Data layer. It is designed so that when changing the data source, no further changes are needed in the application. Communication with the database is done using ORM (Fig. 3). There is one another part called Shared. It is not layer of system, but it is part that contains all classes that are accessible across all layers. There are all business facilities, enums and helper classes.

System consists of several modules. First module is shedule and managment for events of subject like lectures and excersices. Module for plannig and register to tests and exams are also present in system. On this module build next ones for

administration of tests, questions, semestral works and overview of evaluation. Administration of subjects, subject files and users, is done in another moduels for this purpose. Export and import data to and from file provide DB Import and DB Export modules.
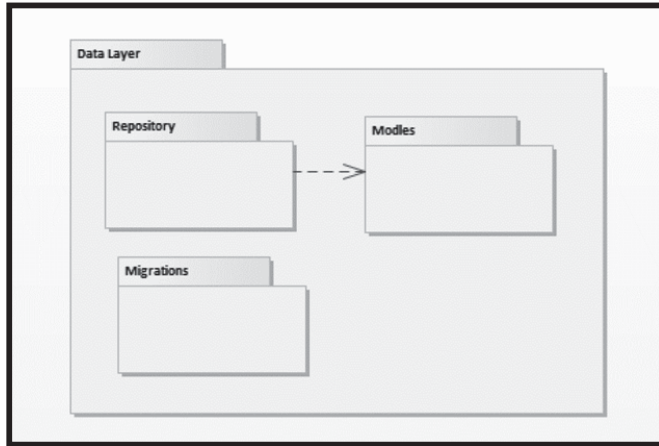

Fig. 3 Package diagram of Data Layer

Access to system is based on user roles. Every user has one role of four roles. Highest role is admin who has all permisions in system. After admin there are two teacher roles – Garant and Teacher. The Garant has some privileges in addition to the teacher. They both can manage subject, tests, etc. Last role is Student, who has not any administration or management rights. He can edit his schedule, register for available events and tests and of course write tests and overview evaluation of himself. Also, there are subject files available for this role, but only for reading.
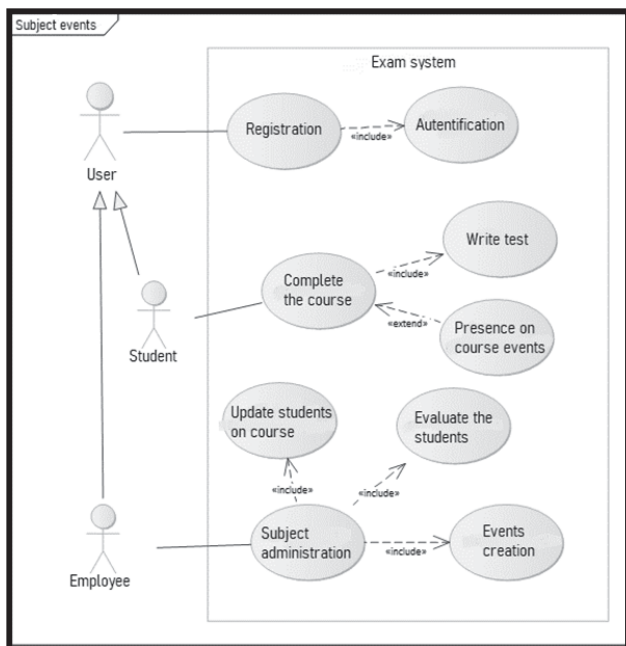

Fig. 4 Process and the administration of subject

V. TEACHER EXERCISES

In this section of the application, the teacher can see all a list of all exercises and lectures during the week (Fig. 5). He can see information about them, such as a teacher who has the exercise, the room where it is lectured, if it is an exercise or the lecture, and number of students signed in.

The column with the exercise reveals more information about it, the list of all students is situated at the left side and signed in students on the right side. The teacher can migrate them between these two sections. Students who are already signed into the exercise are colored green, students who are not signed in are colored red.

The teacher can also add points to the student. He can filter the list of students, click on the student, and add points with the description.

The last tab is for the attendance of students on the exercise. There is a table of all students signed in on the exercise and column for all weeks of the semester. The table contains checkboxes which can be checked if the student is present.

Fig. 5 Schedule

VI. RESULTS

This option is available for teacher, garants and admins. Students cannot see this page because it contains private information about results of all students. On the page are displayed results of tests and exams of students who have selected subject (Fig. 6). The teacher can filter students through their personal number or names.

VII. SEMESTRAL PROJECTS

The teacher can add new semestral project which will be visible for students and they can sign in between two dates which the teacher defines. The teacher must define semestral project name, maximum points for that project and maximum students who can sign in (Fig. 7).

After adding new semestral project, the teacher can add a new assignment with description, so students can have more information about the semestral project and accordingly choose it or not. The assignment is also editable or can be deleted. The semestral project can be also deleted.

When students are signed in, the teacher can see who is sign in and he has all information about semestral projects in the subject.

Name	Test 1	Test 2	Test 3	Final exam	Corrective test
student2 student2 - 111112	10	did not write	did not write	did not write	did not write
student3 student3 - 111113	14	did not write	did not write	did not write	did not write
student4 student4 - 111114	did not write	did not write	did not write	did not write	did not write
student5 student5 - 111115	9	did not write	did not write	did not write	did not write

Fig. 6 Results

Fig. 7 Adding new semestral project

VIII. TESTS

The teacher can see a view of all created tests for the subject. Choosing the test date will call up an action, which is used to call up a query for registered students on the date. The test appears in the next panel, where students are displayed along with check boxes (Fig. 8). If the term also has the option of verbal testing, two columns will be displayed, and the teacher can generate tests for the verbal part at the same time. After that, the option for generating test will appear. If all students are marked for the given test, the teacher can create verbal test for all of them by one click. The main advantage of this implementation is the additional generation of tests, in the case of a student for a term by the teacher after the generation of tests for others. In addition to triggering an action to acquire

students, an action to retrieve topics and questions for a given type of term is also triggered to pre-prepare the data, from which the teacher selects questions for the test.

When the teacher generates the test, a view will be displayed in which he can see all created test topics for the given type of term. We get these topics by connecting to a selector representing the data flow. After selecting a topic in the first panel, the teacher will see a selection of questions on the topic. When selecting a topic, it is possible to enter the number of questions in the test from the given topic. Subsequently, it is possible to choose the questions from which the teacher wants to generate tests. In addition, the option to mark all elements is added to each panel.

Fig. 8 Generating test

After displaying and selecting the questions that the teacher wants to insert into the test in the case of a selective answer, the answer options and the marking of correct and incorrect answers will also be displayed. For questions and answers that have an image associated with them, there is an icon to display the image. The image can be also shown in the full size. The teacher has the option to save selected questions and topics as a generator, usable for further tests in the future.

After successfully generating the test, the teacher can see the generated tests in the test preview. Instead of check boxes, there will be the "Magnifier" icon for students who have generated tests. The magnifier icon reveals an overview of the test and the student's answers (Fig. 9).

Fig. 9 Questions

IX. SUBJECT FILES

There is an option of assigning files to specific subject by teacher. This option is displayed for users of all roles in system.

In higher role mode from student, there is an option to manage these subject files. When for example teacher opens subject files, a button for upload file will appear through which a file can be uploaded to the server where it is stored in a folder for subject files. These files have not any reference to database, so their reference to subject is given by their names which is extended by ID automatically on server. Currently, it is possible to upload only files of some types such as ".jpg, .png, .jpeg, .gif, .pdf, .txt".

As it is mentioned before, files are assigned to the specific subject. The subject is chosen by implemented functionality of subject filter in the header part of the page. Uploaded files are displayed in one list and next to each of them, there are two options for changing visibility of file to students and deleting file from server (Fig. 10).
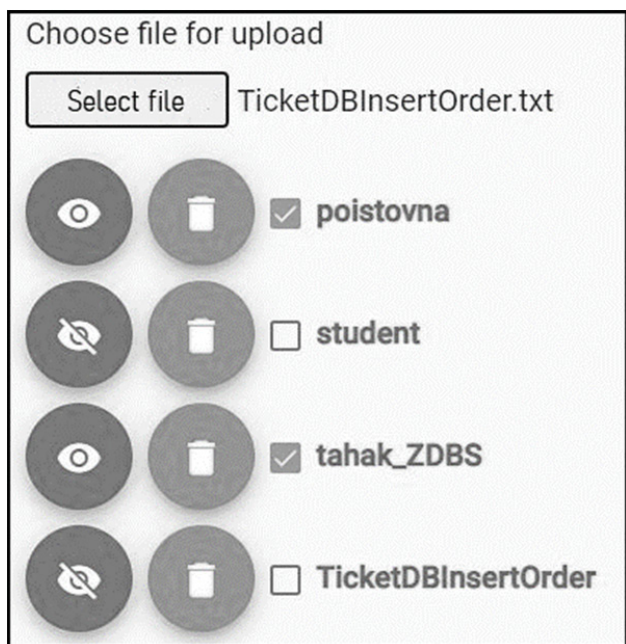

Fig.10 Subject file (role teacher)

Student role user can see view of subject files only for reading. He has no permission to manage files. As it is showed in the next image (Fig. 11), this user sees files as list of names of these files and list of frames whose content is file content. By clicking on a file name, the file will display in new tab of a browser.

The functionality of files for subject has been firstly added mainly as part of students tests where student can open necessary files for the test writing, but on the other hand it can be used for uploading another study material for students. Also, it can be extended for another file types.
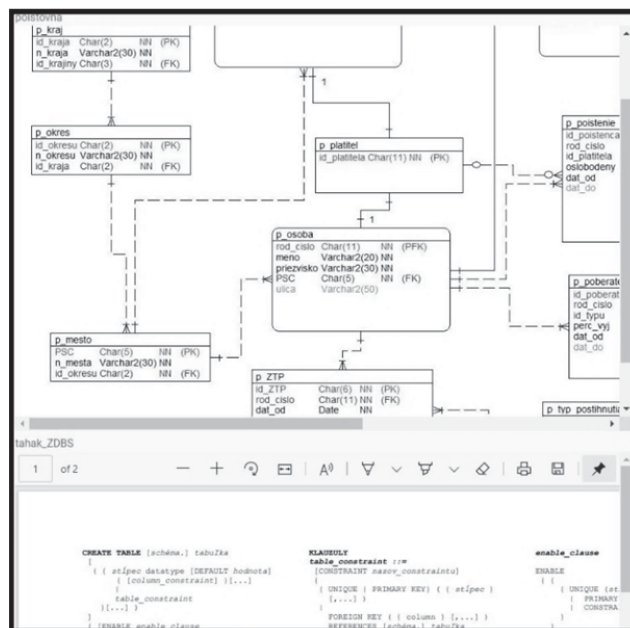

Fig. 11 Subject file (role student)

X. THE PURPOSE OF THE IMPORT AND THE EXPORT

Because of the system is new, data about test questions, test answers, students or the new ones which are newly created for majority of subject which will use the new Exam system need to have import and export functionality. The questions should contain text of the question and there should be a possibility to also contain an image. Questions can be of various types, such as a question with options, a question without options, only with text area for writing the answer and a question with images.

The system currently supports three types of data formats: CSV, XML and JSON. These three types of formats are for all data which will be imported or exported with the system. The user of the application has many options to customize which will be imported/exported. He can change names of the columns of the exported file, he can choose which columns from the database will be exported, the order of them could be also changed and there can be also applied limit to number of rows exported (number of rows or percentage of rows of whole table).

The user may also use the functionality of creating functions for adjusting columns of exported table or imported file (calculate average of the values, minimum, maximum, …).

Users who log into the application have different roles, such as a student, a teacher, a garant and an admin. Our parts of the system are available only for teachers, garants and admins. The students cannot have the permission for exporting and importing data to database for security reasons. They would also have access to all questions and answers of the subjects which they study.

After logging in the user can see navigation bar at the left part of the screen. In the case that he has permissions to import/export data, he can see a DB Import/Export tab. From there he can choose, if he wants to import data, export data, or create a new function.

XI. THE EXPORT FUNCTIONALITY

The system offers the export functionality in its menu on the left side of the navigation menu. (Fig. 12).

First thing which user will see is autocomplete combo box, where user can type or choose from available tables in database. The list of table contains all tables which can be exported from the database. On very left, there is vertical list of attributes of chosen table, where each one is represented by its real name in database. Next to this there is similar list of columns names, but in this case names are editable. Columns names in exported file will be set by these edited ones.

Because of user may not want to export all full records (all attributes), there is another option. For this purpose, there are two hor Ɪꞏ ntal lists one above a 𝗼the r whe ꬲ first one represents not selected columns. The second one contains selected columns. By default, first list is empty and in the second one there are included all available columns. In this option user can deselect or select columns which will be exported, column name can be selected in horizontal list and by up and down arrow buttons can move these columns between lists. Also, user can change order of selected columns by left and right arrow buttons. It will change their positions in the exported file.

If user wants to adjust exported values of some attribute or add some new independent value, he can do so by using the functionality for setting new column. After that, setting bar will appear on right side of screen where user will choose function from those which are available to him. Because result of this function will display same as another column, user must set the name for this column. If the function has some input parameters, user can set value for these parameters as constant or set it as name of column form selected table while he must obey the type and length of parameter.

Another option is to order records. Records are ordered by one or more columns. In SQL Server, records cannot be ordered by attributes of types "text", "ntext" or "image" [9]. When a user clicks on check box for order records, order setting will appear bellow. Firstly, there is only one combo box containing columns by which order can be done. The user selects one column and choose order type (ascending or descending) by radio button click. When first column for order is selected another combo box will appear beyond previous one and this is repeated while user chooses columns for order.
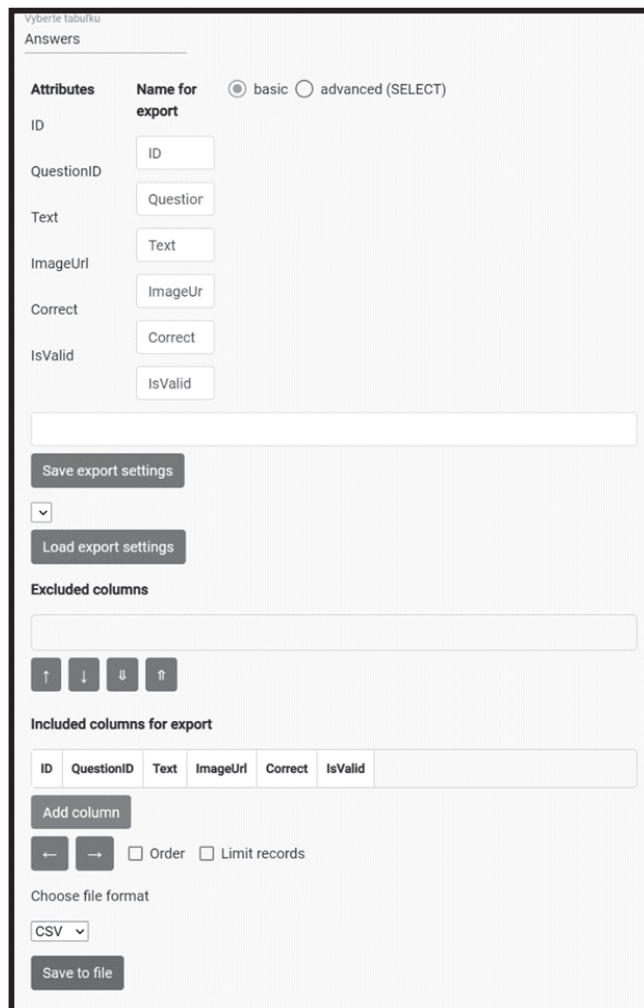

Fig. 12 Export

Sometimes there is not necessary to export all records from table. If table contains a lot of records and user needs only prepare export settings, he can limit records by available option, which is activated by checking limit records check box. The number of records to be exported is written into text area by user. Next to this input user can set to export precise number of records or export proportion of all records by choosing this option. Also, user sets the order type of limiting records, column for order records and optionally column for partitioning limited records.

Second option for exporting desired data is by writing pure SQL select query. The user has more options to set his own export. On the other hand, he has must by familiar with writing SQL queries in SQL Server. The server will not allow user to run some DDL command.

XII. THE IMPORT FUNCTIONALITY

Choosing the import button will redirect the user to the import page (Fig. 13). At this page he will be asked to choose a file which contains data of questions which he wants to import, to choose a file containing data of answers and the path of the folder where images for questions and answers will

be stored. Files must be in correct file type: CSV, XML or JSON. The system will not allow a file with different extension.

After choosing files and filling the folder path, two tables will be shown. The first table is for mapping the question file with a question table in the database, the second one is for mapping the answer file with an answer table in the database. The tables have the same structure, the top header contains names of columns in the file, the names which user can modify directly in the file or when exporting it. The left panel of the table contains names of the columns in the database, these names are unchangeable for the user. The contents of the table are buttons with which the user maps the column in the file with the column in the database. There is also possibility to add new column which data can be filled with a created function. After these steps data can be imported to the database. If there is an error, the file containing rows with the error plus the error description, will be downloaded to user's computer, so he can see the error and repair it. Otherwise questions and answers are stored in the database and can be used for future work.

When the user chooses a file, the extension of it is read. Depending on it, the correct parser is chosen. If the extension is CSV, the first row of the file contains headers which will be displayed in the top row in the table. Other rows are parsed into lines, every column is separated from the other ones with a semicolon. The result is saved into a variable.

Every button in the table has a value constructed by an index of a row and an index of a column in which it is. After every user's click in the table buttons, value of the button is registered and mapped into the array. After selecting column in every row, the array contains indexes with which it is possible to map file data with database columns. For example if database table has two columns and there are four columns in the file and user selects third button for the first column of the database and first button for the second column, the array of indexes will contain the index of the third button (2) and the index of the first button (0), so the array will look like this [2, 0]. This mapping works for both tables: questions and answers.

After that the user can import data to database. The variable containing data from the file is parsed once again. The columns in lines are reassembled to the correct order, the order from user's choices he made with buttons in the tables above the import button. Columns are checked if they contain the extension of the image file, such as .png, .jpg, .jpeg. If they do, the path to the image folder which user put into the area for it, is added before the image file name, so the column in the database will contain full path to the image on the server.

The function will try to insert first question from the file. If the import is successful, answers connected with that questions will be also imported to the database. The function will go through all questions from the file and will try to import them. Questions and answers from the file are linked with the column which will not be imported to the table. The column contains the index of the question in file. For example, the first question has this column filled with index 10. All answers in the answer file will have column of the question filled with the index 10. If the question cannot be added, no answers for that question will be added neither.

In the backend the line with all information about one question/answer is read and data from the columns are added to correct columns in the database. The result which the backend will send to frontend is either empty string, that means that everything would be inserted correctly, or with the error, that means that something would gone wrong. If that is the case, the user will be notified.
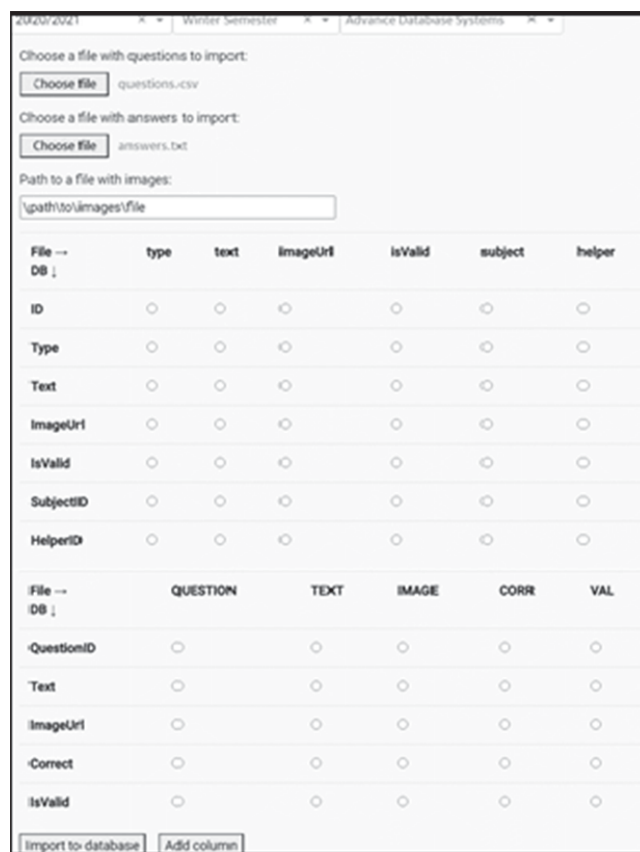

Fig.13 Import

XIII. CREATING USER'S FUNCTIONS

The user has an option to create his own functions. These functions can be used for the exporting or for the importing data. After choosing this option from the navigation bar, the function page will appear (Fig. 14). This page contains two options the user can choose from. He can write his own function with correct SQL syntax, from the declaration to the end of the function. This option is recommended for more advanced users who know the correct syntax of the Structured Query Language and they know to create the function correctly in this language.

The second option is for less advanced users, but they also need to know the correct syntax of SQL for writing the body of the function. The user has to fill information about the new function, its name, the return type, he can also add parameters by writing the parameter name and choosing its type, after filling the information about parameter and clicking the correct button, the parameter will be shown to the user in the table, so he can see, which parameter he already added. The same functionality works for the variables of the function. The

table with variables will be shown next to the table with parameters. At the end, the user must fill the last part of the function, its body. He must write it without syntax errors, otherwise it cannot be added to the system.

Both approaches require some knowledge about databases, that means that not every user can create his own functions. Recommendation for users without the knowledge is to ask their colleagues who have experience in creating SQL functions.

Creating functions is the functionality which can be used by teachers, garants and admins of the system. Students are not allowed to create their own function in the system. Firstly because of security reasons and secondly because they cannot use them anywhere, it would be useless for them to create them. The option for creating function will be hidden for them in the navigation bar of the application.

The security control for SQL injection is also added, the user cannot create function which will delete the table from the database or the function which can delete data from the database. It would be dangerous to let these options not secured, so the everyone could damage data in the database. The functionality for dropping tables and deleting information would be accessible only from the database administrator who has full access to the database and who knows what he is doing. This functionality is not possible to access with the application, it must be done from the software which has direct access to the database, such as Microsoft SQL Server Management Studio, DBeaver, HeidiSQL or similar database management software [9]. We currently use Microsoft SQL Server Management Studio because the interface of the program is intuitive and user friendly and we use it also because our predecessors were using it, so we continue with this trend. Because this tool is developed by Microsoft company, work with Microsoft SQL Server is smooth and intuitive [9].

After choosing one of the options (complete SQL function code or composite creating of the function), the user can create and save the function to the system. When user chooses one of the options, the other one will become disabled, so he cannot divide creating of the function between presented two options.

Generally, in database systems works on role system. So, it is in MS SQL Server. User can grant privileges to other users on database objects if he has granted this privilege [7] [9]. Functions are created under one administrator account in database and the privilege to access them is granted to the user who created them or to others, depending on the option of the function creator.

When the function is saved in the system, it is available for the usage in the export and the import. The return value of the function can be used as the column when exporting data, so the user will have the value in the exported file. It can be also used in the import part, where the user can add new column which will be filled with the return value of the function, so it will be imported to the database table.
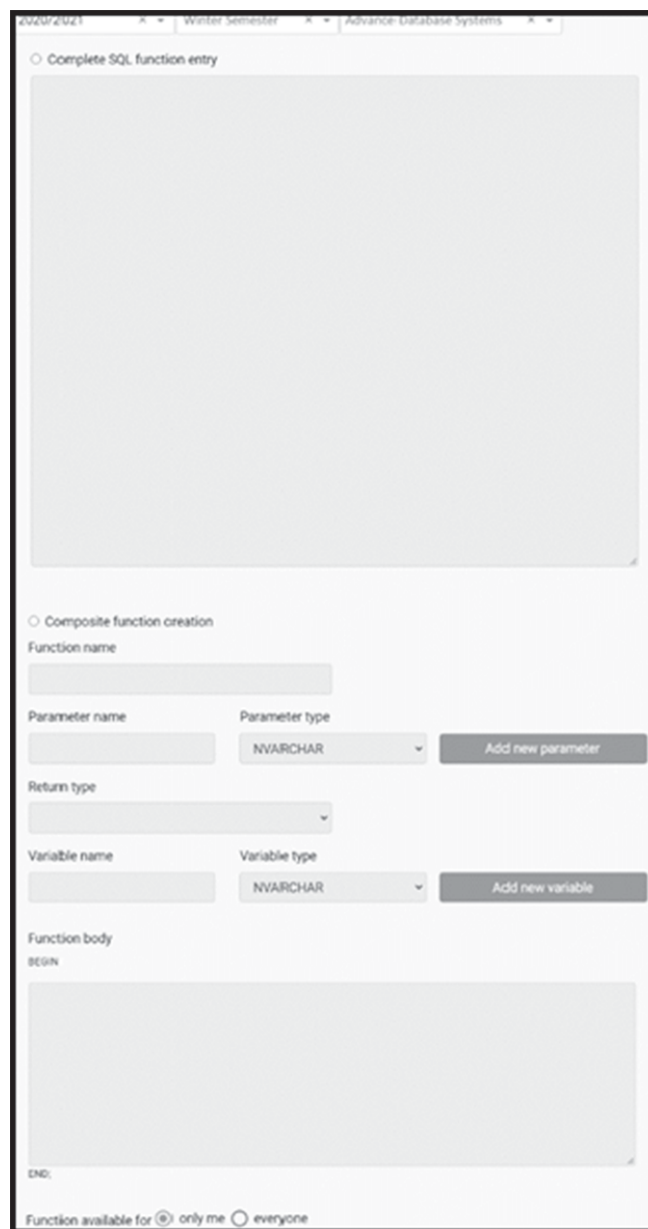

Fig.14 Function creation

XIV. ADMINISTRATION

The administration is divided into multiple sections: the administration of users, the administration of subjects, the administration of modules, the module assignment.

The administration of users contains a list of students and basic data about them, such as name, student group, grade, login and so on (Fig. 15). The teacher can filter through these records to find information about student he is looking for. The teacher can import new students via file which has to have the correct format (the teacher can see this format on the page). This section also supports student assignment to the subject (Fig. 16), the teacher can see students who are assigned to the subject and the students who are not, the teacher can transport students both ways. The teachers can be

also filtered, and the admin can assign them to the subject or unassign them.

Fig. 15 Student administration

Fig.16 Assigning student to the subject

The administration of subjects contains a list of subjects, their names, subject codes, and the information if they are actual or not (Fig. 17). The administrator can edit the information about a subject by double clicking on it. The teacher can also manage weeks of the subject during the semester and he can set criterions to signing into the exams or tests (Fig. 18).

Fig.17 Subject administration

Other functionality concerns the creation and allocation of modules and the data model used for the functions and format of messages sent to a given module (Fig. 19).

Only a user with the admin role defined has access to this view. The admin gets to this view via the navigation and item

management modules. When implementing modules, endpoints can be dynamically inserted without interfering with the system.

Fig.18 Criterion creation

The view for assigning modules is assigned to the admin and guarantor roles. The user can access this view via navigation by clicking on "Assign modules". In the image bellow, on the left there are all unassigned modules of the subject selected from the filter, and on the right are assigned modules for the subject.

The created database module is intended for the subjects advanced database systems and database systems. It is mainly used to facilitate the writing and checking of the select statement for students. Using this module, it is possible to check the syntax of a written select, separating all unauthorized types of database queries except select.

Fig.19 Modules assignment

XV. CONCLUSION

The system was extended with functionality of subject files used for students. Currently the exam system is fully operational and is already deployed on faculty server.

The very significant feature of the system is the import export module. It can be used for importing and exporting data to and from the system. Currently it is used for the data about subject test questions and their answers, the information about students who are signed up to two subjects supported by the exam system, but it can be used for all subject and more data through the faculty and also the university in the future. It would be more secure way of importing and exporting data because it will be done by the faculty application, not the third-party one, which could track some data. The module can be upgraded to support more formats, and, in the future, it can be the only import and export module for the university which will be needed.

For the exam system is still partially in testing mode, there are many things that need to be upgraded, regularly updated or which are not complete. Maintenance is important in a project like this as well so there is important to have active administration personnel which is capable of interfere with running system.

As students are already using this system it can help developers to catch most of the bugs and create user interface of system more intuitive and friendly for them.

Students are already more satisfied with this new exam system than they were with the older ones. It is more pleasant to use, the design is more modern, and it has more functionalities than it had before.

The exam system is currently used by two subjects: Database systems and Advanced database systems, but in the future it will be used by more and more subject until every subject on the Faculty of management science and informatics and then whole University of Žilina will use this system.

The system has a strong potential to be the leading exam system of the whole university if the development will not stop and the system will be upgraded on the regular basis.

In the future, we would like to extend the solution with the extended transaction based architecture, so each student can practically execute any data manipulation language script to test the syntax and treatment management.

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