Visualization Modeling of Management Processes in Knowledge-Oriented Systems

Lubomyr Petryshyn[a], Mykhailo Petryshyn[b]

[a] AGH University of Science and Technology, Mickiewicza str. 30, Cracow, 30-059, Poland
[b] Vasyl Stefanyk Precarpathian National University, Shevchenko Str. 57, Ivano-Frankivsk, 76018, Ukraine

Abstract

Modeling of information processes in knowledge-oriented systems allows to reduce the cost of development and operation of such complex systems. The proposed method of information models visualization allows to display processes in graphical form and simplify mutual understanding between the customer and the developer at the stage of analysis and design. The visualization models and a simplified example of developing.

Keywords 1

Knowledge-oriented systems, process analysis, visualization modeling, distributed systems, management, linguistic school

1. Introduction

The necessity of increasing the management efficiency of distributed knowledge-oriented systems of distance learning under quarantine restrictions requires the use of information technology, that provides displaying of system status and system management processes in real time [1]. Analysis and visualization of management processes avoid the psychological barrier and misunderstandings between the user and the developer of the information system, as well as reduce the cost of development, implementation, and maintenance of such complex systems [2-4].

The purpose of development is to present visual modeling methods of knowledge-oriented systems, as well as the development of a management system on the example of a linguistic school. During the analysis of the structure of the research object, key problems were identified and methods for their solution are offered, tools for optimizing management processes and ensuring functional and non-functional requirements to the system.

The novelty of the work is the presentation of systems analysis techniques, in accordance with international standards [3-13], which, during the implementation in the process of information modeling for knowledge-oriented systems, provides visualization of management processes and simplifies the understanding of their structure and course.

The practical aspect is a comprehensive analysis of the structure and course of management processes of knowledge-oriented systems, avoiding misunderstandings in the tasks formulation and user requirements gathering, as well as reducing the cost of creating and operating management systems.

Basic user requirements for linguistic school process management system:

- language learning process control,
- electronic client registration,
- creation of client account,
- client activity monitoring,
- communication with the linguistic school,
- client financial account creation,
- automation of the payment process,

COLINS-2021: 5th International Conference on Computational Linguistics and Intelligent Systems, April 22–23, 2021, Kharkiv, Ukraine
EMAIL: l.b.petryshyn@gmail.com (L. Petryshyn); m.l.petryshyn (M. Petryshyn)
ORCID: 0000-0003-4168-3891 (L. Petryshyn); 0000-0001-6319-3768 (M. Petryshyn)

- linguistic school financial control.

The result of the system creating is websites and mobile applications, the use of which should increase the efficiency and competitiveness of the linguistic school in the market of educational services. Such knowledge-oriented systems should transparently facilitate communication between customers and the company and, if desired, the use of loyalty status under loyalty programs.

A convenient way to enter a language school without the need for a personal visit to the institution, electronic document management, transparency of the recruitment process for language courses and their course, the possibility of statistical processing of client metadata (their age, gender, address, motivation to start courses, learning progress) activities, a list of the main effects of the management system implementation. The automated payment process allows you to constantly monitor unpaid receivables and the overall financial condition of the linguistic school. An important factor is to ensure competitiveness in the market of educational services through promotions and PR activities.

2. General system analysis

2.1. Enterprise characteristics

The language school operates as part of territorially dispersed branches and offers individual and group courses in five languages (English, French, German, Italian and Spanish). In the conditions of quarantine, the urgency of conducting online courses increases.

The guidance of the linguistic school set a task to automate the process of enrolling clients in courses. The linguistic school has full-time teachers, employment contracts, and part-time teachers. There is also an accountant in charge of the marketing and promotion department, secretariat staff, and technical staff (fig. 1).

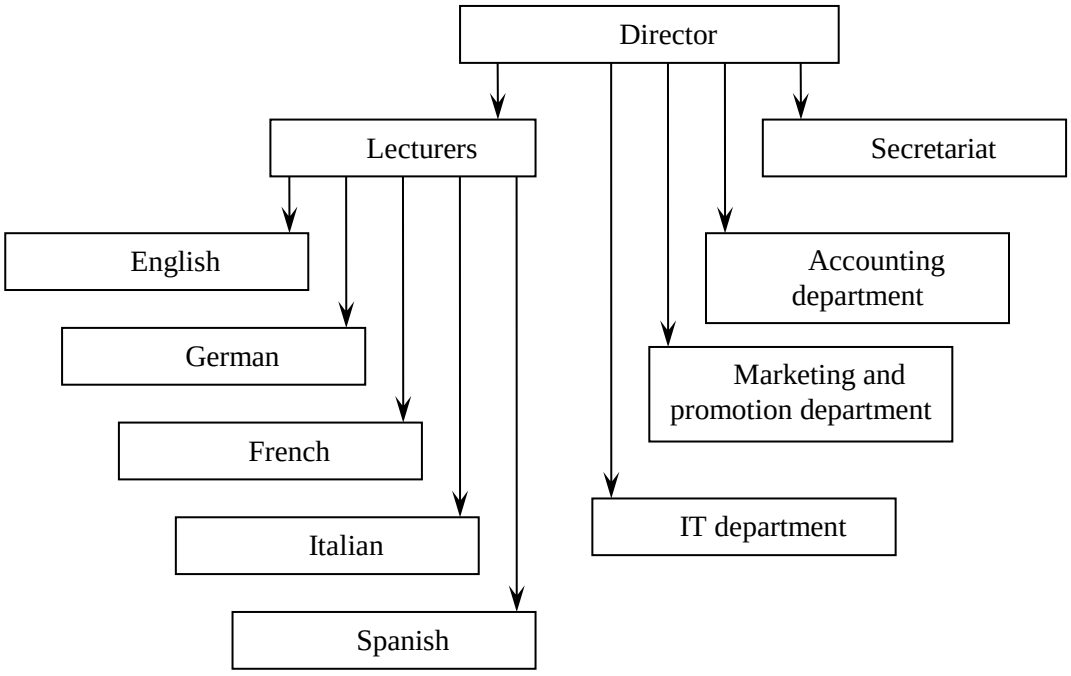

Figure 1 Graphic organizational structure of linguistic school

2.2. The context of the system functionality

The system is used through a mobile application or an Internet browser. This allows to communicate with users, register and exclude from the course, control payments, as well as receiving and processing customer comments. Teachers have access to accounts in the system, protected by a login and password received from the owner of the language school. School clients register in the

system independently. Their records are confirmed by name, surname, telephone number, and e-mail address. The customer of the system requires the support of a maximum 50 teachers, 150 students, and 3 owners.

2.3. User characteristics

System users are potential customers, current students, teachers and the school owner. Pupils and students who use mobile applications are a significant target group. Also, many clients use the services of the school on the recommendation of the employer or on their own initiative. The composition of teachers changes adaptively to the number of students.

2.4. Basic system requirements specification

The system provides users with the following capabilities:

- review the current offer of courses and teachers in order to compare with other schools and choose a course;
- registration and secure login to the system with access to personal data and the ability to perform all functions of the system;
- making payments in the application in order to increase efficiency and avoid cash transactions;
- commenting on the current functioning of the school, teachers and the atmosphere of classes.
- access of teachers to information about their courses, their participants and assessments, in order to control the course of the didactic process;
- flexible system of evaluation of the educational process and monitoring of the progress of knowledge acquisition.
- the owner of the language school has access to statistics on the number of students, the most popular courses and control of the company's financial condition.

2.5. Functional system requirements

1. Functional requirement: ***Registration in the system***
Definition: creation by each client of school of the account in system.
Enter: Password, email, name, phone number.
Exit: After the registration is completed, the system redirects the user to the login tab.

2. Functional requirement: ***Login***
Definition: logging in with authorized users. After logging in, users are able to use the available features depending on whether he is a student or a school employee.
Login: Login and password
Exit: by laying out.

3. Functional requirement: ***Registration for the course***
Definition: independent registration of users for the selected language course.
Input data: choice of school location, language, level, study group.
Exit: After saving, the notification panel will display a message about registration and course details (language, teacher, level, class dates, number of people in the group, school location, funds and date of payment).

4. Functional requirement: ***Cancellation of the course***
Definition: self-cancellation of the course by the user.
Input: Select an account and cancel it.
Exit: After canceling the account, a message is generated in the notifications panel.

5. Functional requirement: ***Review of the offered language courses***

Definition: acquaintance of users with the offer of school.

Access: The menu includes the "Courses" tab, and the "Filter" function allows the user to view the courses of the respective language, level, teacher and educational institution.

Exit: After selecting a specific course, the registration option appears. The "Back" button redirects the user to the main menu.

6. Functional requirement: ***View current courses***

Definition: Displays to the user the course to which he is enrolled.

Login: "My courses" option in the main menu of the system

Exit: After selecting the appropriate course, the "Course Details" option appears, which directs the user to course details, homework, lesson topics, grades, and payment information.

7. Functional requirement: ***Payment information***

Definition: the user's choice of payment method and its execution.

Access: via the main menu "My courses"> "Details"> "Payment".

Exit: After selecting a specific course and the "Payment" button, the program displays the user the price of the course and payment options in installments. After selecting the appropriate type of payment, the program displays the types of payments: BLIK, transfer, payment card.

8. Functional requirement: ***Payment of receivables***

Definition: deferred payment by the user of the course.

Input: Choose a payment method.

Exit: redirection to the banking program.

9. Functional requirement: ***Reviews of courses and language school***

Definition: allows students and teachers registered in the system to comment on the quality of classes and individual teachers.

Access: In the main menu, the "Reviews" tab redirects to the "Leave Feedback" and "View Feedback" options bar.

Exit: The generated feedback is added to the list and becomes available to other users.

10. Functional requirement: ***View comments***

Definition: the ability to view arbitrary users, including those who are not registered in the system, available comments on the quality of classes and individual teachers

Access: In the main menu, the "Comments" option goes to the panel that contains the "Leave a comment" and "View comments" options.

Exit: A list of available comments is displayed.

11. Functional requirement: ***Information about courses for teachers***

Definition: displays information about the schedule of teachers, the number of students in groups, passed and planned lesson topics (optional).

Access: through the main menu of the teacher, the tab "My courses". Ability to choose a specific course.

Exit: course information is displayed.

12. Functional requirement: ***Statistical information***

Definition: allows you to view statistics on the number of participants in individual courses over a period of time, the popularity of individual languages offered by the school, and the popularity of individual teachers. This feature is available to the language school owner.

Access: on the main panel, after the login of the school owner, the option "View statistics".

Output: interface with grouped statistics, the ability to select the requested period.

3. Methods

3.1. Context diagram

The context diagram shows (fig. 2) data streams of interaction with external objects in the system. Examples of such objects are the external components of the system, institutions, users. The diagram shows which data is entered into the system from the outside, which is processed inside the system, as well as which is output by the system to the outside.

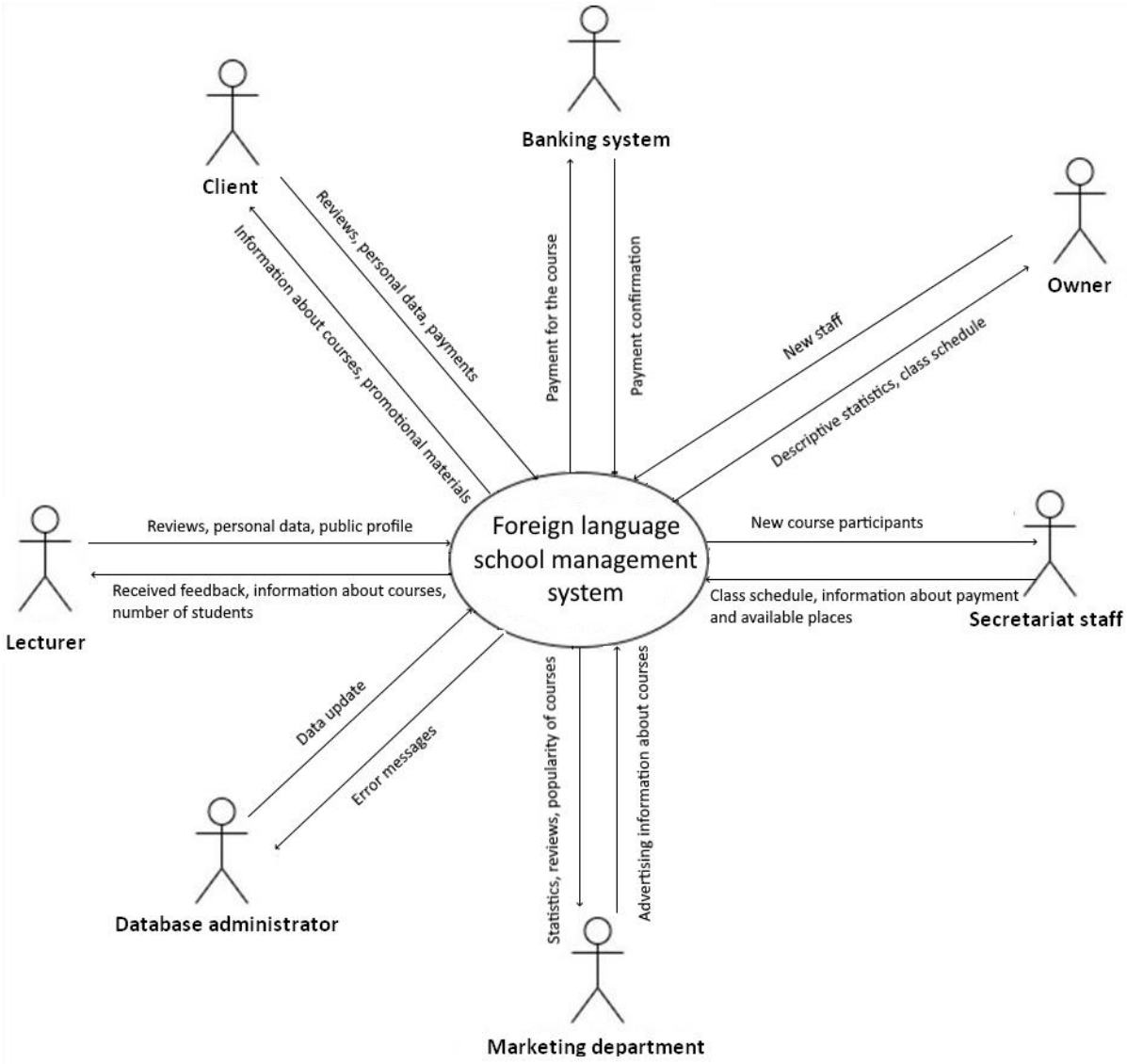

Figure 2: Context diagram

Based on the formulated user requirements, the system management process was decomposed into two subprocesses: user registration for the course and financial calculations for training.

3.2. BPMN models

BPMN notation is used for graphical display and analysis of business processes in the system. A characteristic feature of BPMN-models is the unambiguous representation of Workflow-processes and ERP systems.

Figure 3 shows the BPMN model of user registration for the selected course.

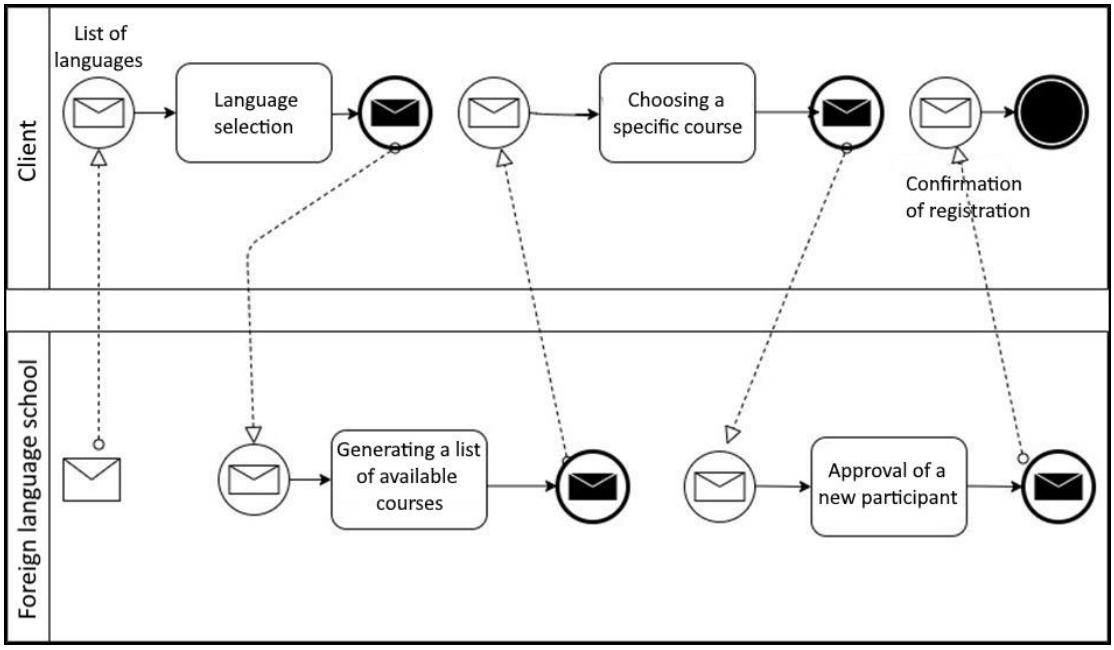

Figure 3: Schematic of the BPMN sub-process of user registration for the course

Figure 4 shows the BPMN model of the course payment subprocess.

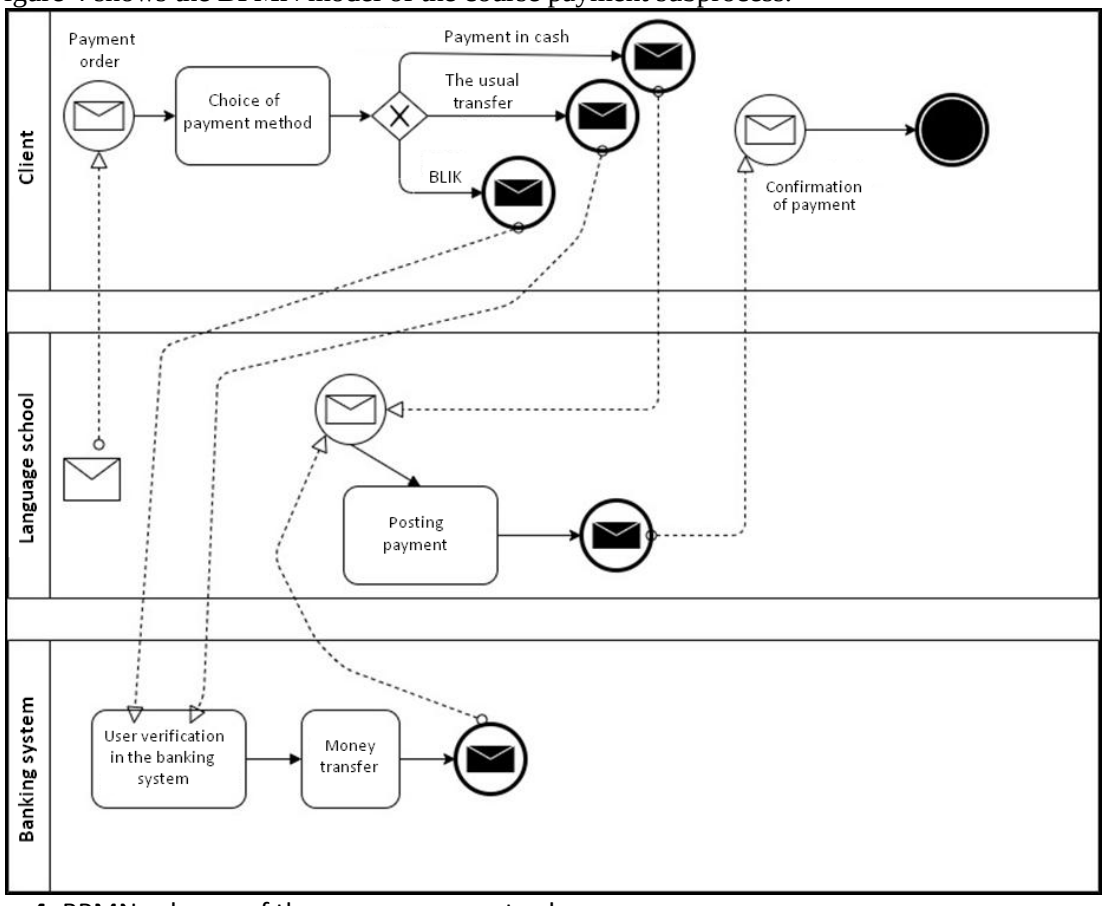

Figure 4: BPMN-scheme of the course payment subprocess

The result of the decomposition of the processes of the control system is the definition of two system subprocesses: enrollment in the course and payment [7], the composition of which for the two components of the processes are given in Tables 1 and 2. The tables show the following abbreviations of system actors: SE - an employee of the secretariat, ITE - an employee of the IT department, DBA - database administrator, BIS - the bank interaction subsystem, SO - school owner.

Table 1
System operations for the sub-process "enrollment in the course" with a specified duration, start and end time.

Document	Title	start time	duration	end time	description
D1.01	Customer choice of language	0	5	5	SE 01
D2.01	Compiling a list of available courses	5	1	6	SE 01
D3.01	Choice of course by the client	6	10	16	SE 01
D4.02	Appointment of a new course participant - entry in the database	16	2	18	DBA 02
D5.03	Create a subscription email confirmation	18	1	19	ITE 03
D6.03	Sending confirmation to the e-mail address provided by the customer	19	1	20	ITE 03

Table 2
System operations for the sub-process "Make a payment" with duration, start and end time.

Document	Title	start time	duration	end time	description
D7.01	Sending a direct debit to the customer	0	1	1	SE 01
D8.01	Customer's choice of payment method "regular transfer"	1	3	4	SE 01
D9.01	Sending transfer data to the client	4	1	5	SE 01
D10.04	Customer verification in the banking system	5	2	7	DBA 04
D11.04	Funds transfer to the account of the language school	7	4	11	DBA 04
D12.01	Posting payments	11	30	41	SE 01
D13.02	Create a confirmation of payment by e-mail	41	2	43	ITE 02
D14.03	Sending confirmation to the e-mail address provided by the customer	43	2	45	SE 03

3.3. Matrix models

Matrix models of the general process of system management reflect two subprocesses defined by the customer: enrollment (fig. 4) and payment (fig. 5). This model allows visualizing the execution of individual system operations by the relevant departments on a time scale [6, 7, 9, 14, 15]. Each of the cells determines the type of system operation (DX), the unit in which it is performed (OY), the start time is shown in the upper left corner, the execution time - in the upper right corner, the info exchange time - above the arrows, and the system network, which are indicated by arrows.

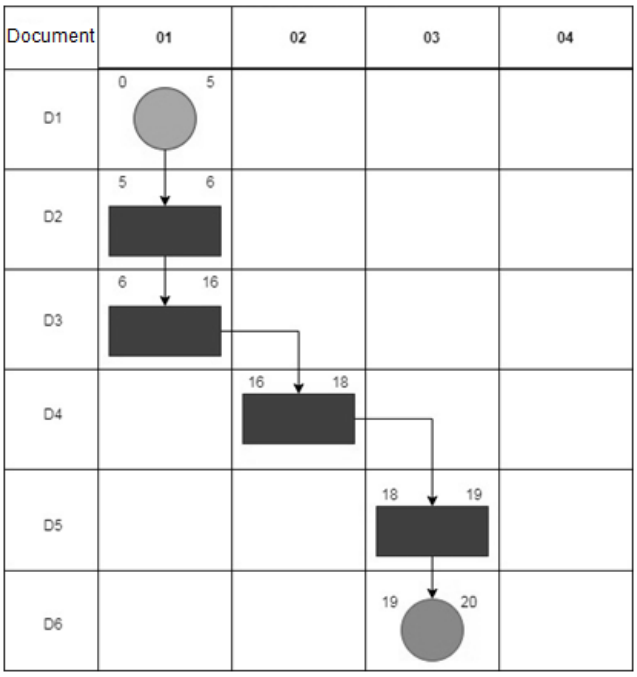

Figure 4: Matrix model of the subprocess "Enrollment in the course"

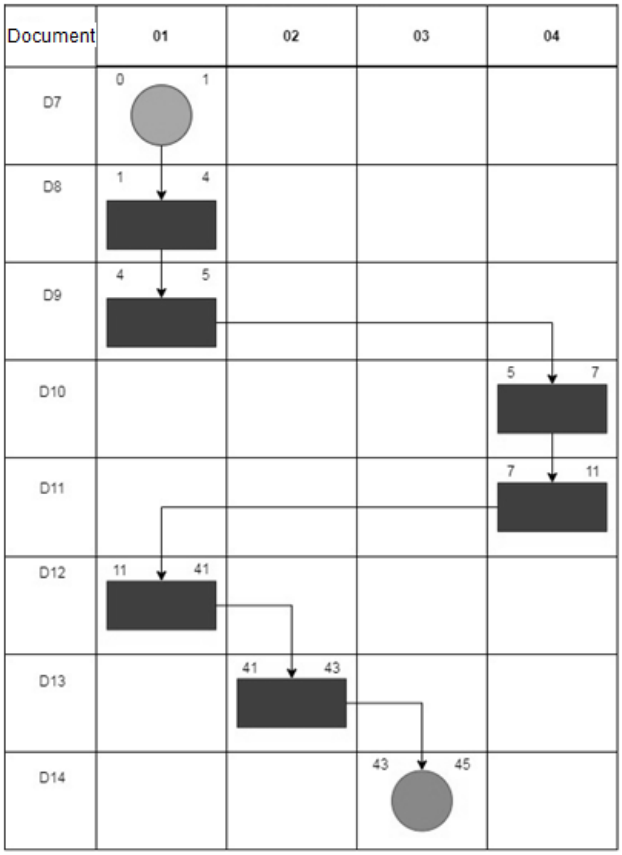

Figure 5: Matrix model of the subprocess "Payment"

3.4. Gantt models

Gantt's models allow to visualize in the time scale of system operations in each of the subprocesses (fig. 6, 7).

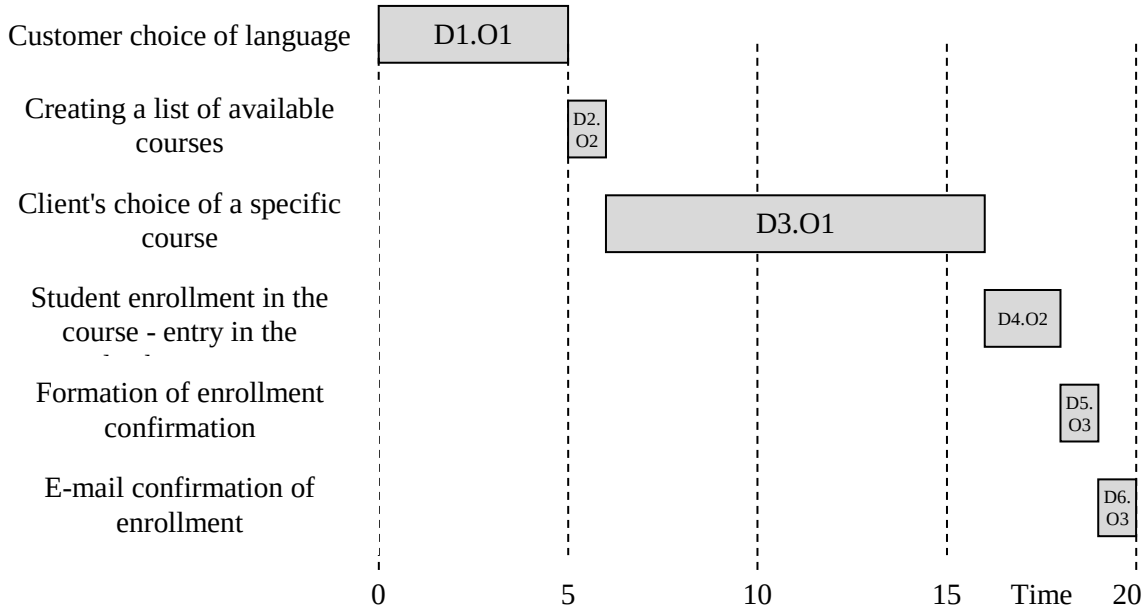

Figure 6: Gantt chart for the language selection subprocess**.**

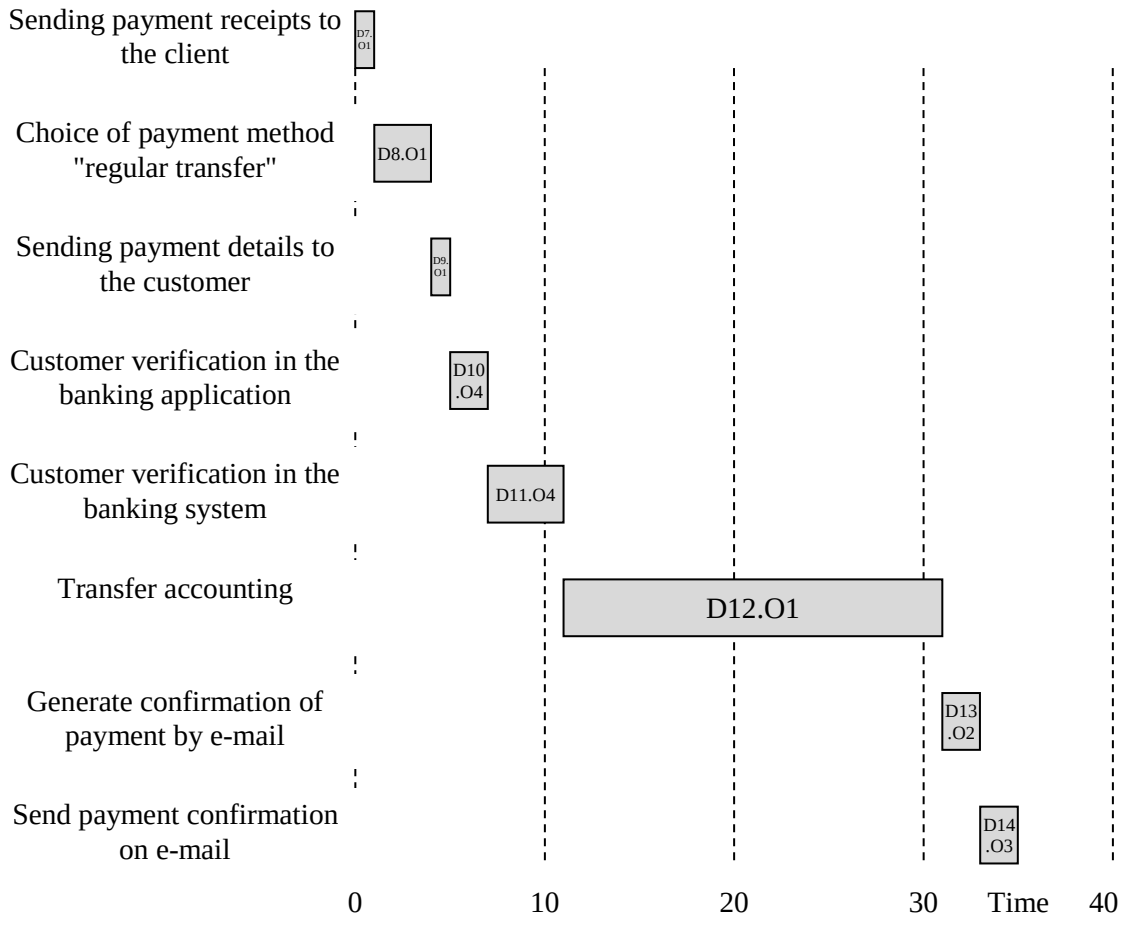

Figure 7: Gantt chart for the payment subprocess

3.5. Models "network graph"

The "network graph" model (fig. 8, 9) is a basic, derivative of Gantt's model [4, 9, 14], allows to pass to UML-modeling and represents such basic system parameters, as times of the beginning and the end of system operations, their performance in units, as well as the structure of the system and communication channels.

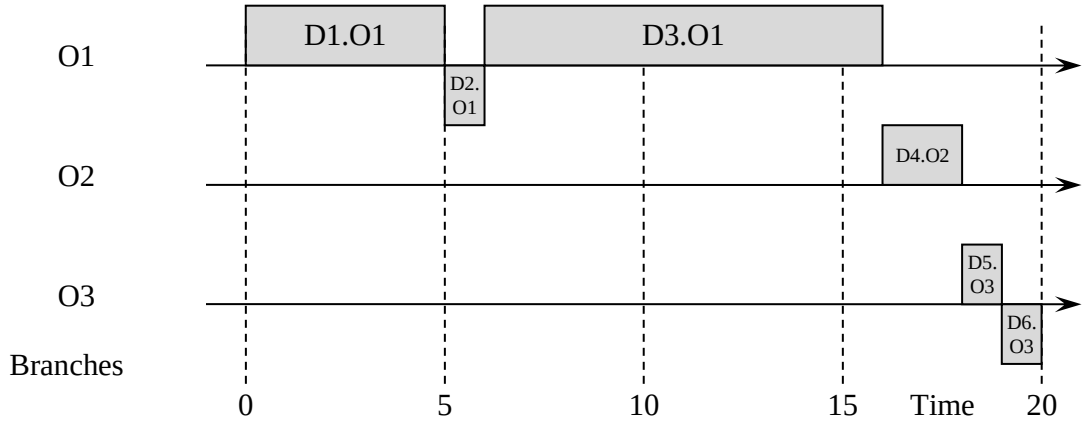

Figure 8: Network graph diagram for the language selection subprocess

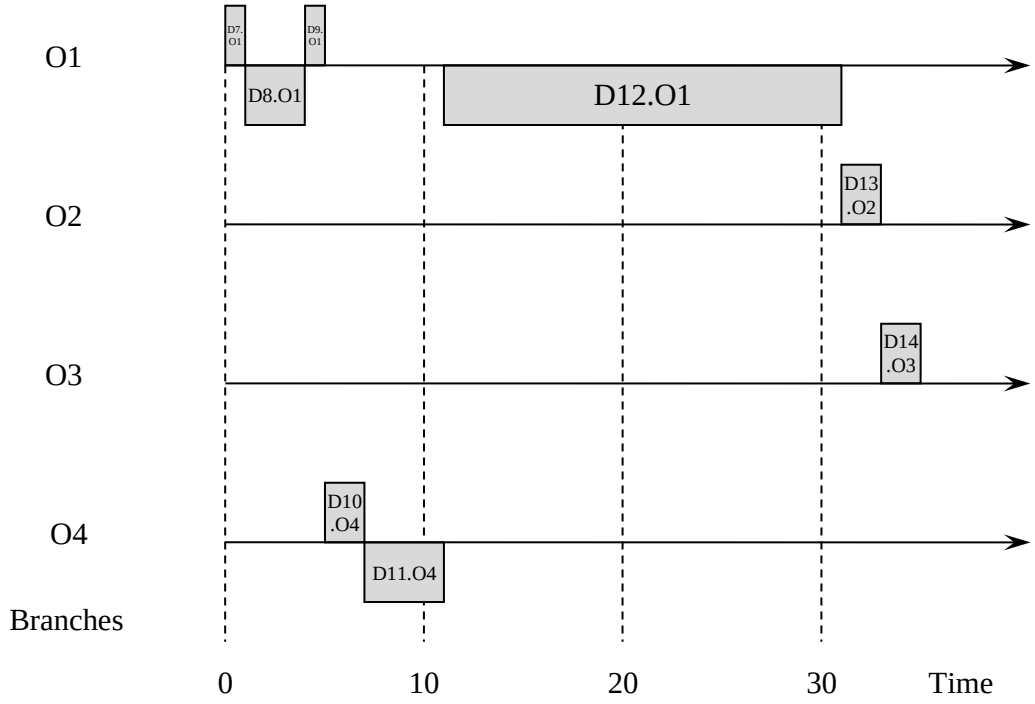

Figure 9: Network graph diagram for the course payment subprocess

3.6. Combined time models for performing system operations

A combined time model (fig. 10, 11) is used to estimate the total computational load of the control information system [2-10]. However, this graph does not show the units in which individual system operations are performed.

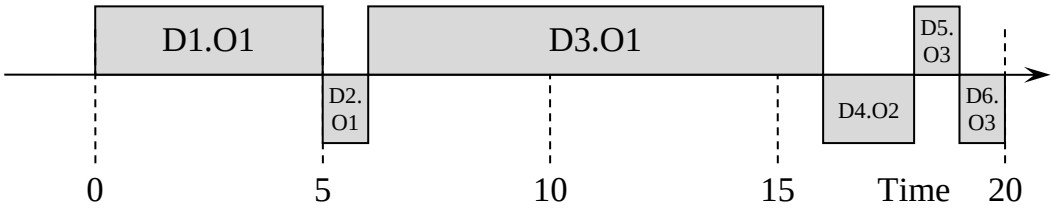

Figure 10: Combined time model for the language selection subprocess

Figure 11: Combined time model for the payment subprocess

3.7. Block diagram of the algorithm for performing system operations.

Based on the combined time model, a block diagram of the program algorithm for system operations execution (fig. 12, 13) is built, which on the basis of object-oriented programming allows the fast implementation of the management system [2-10].

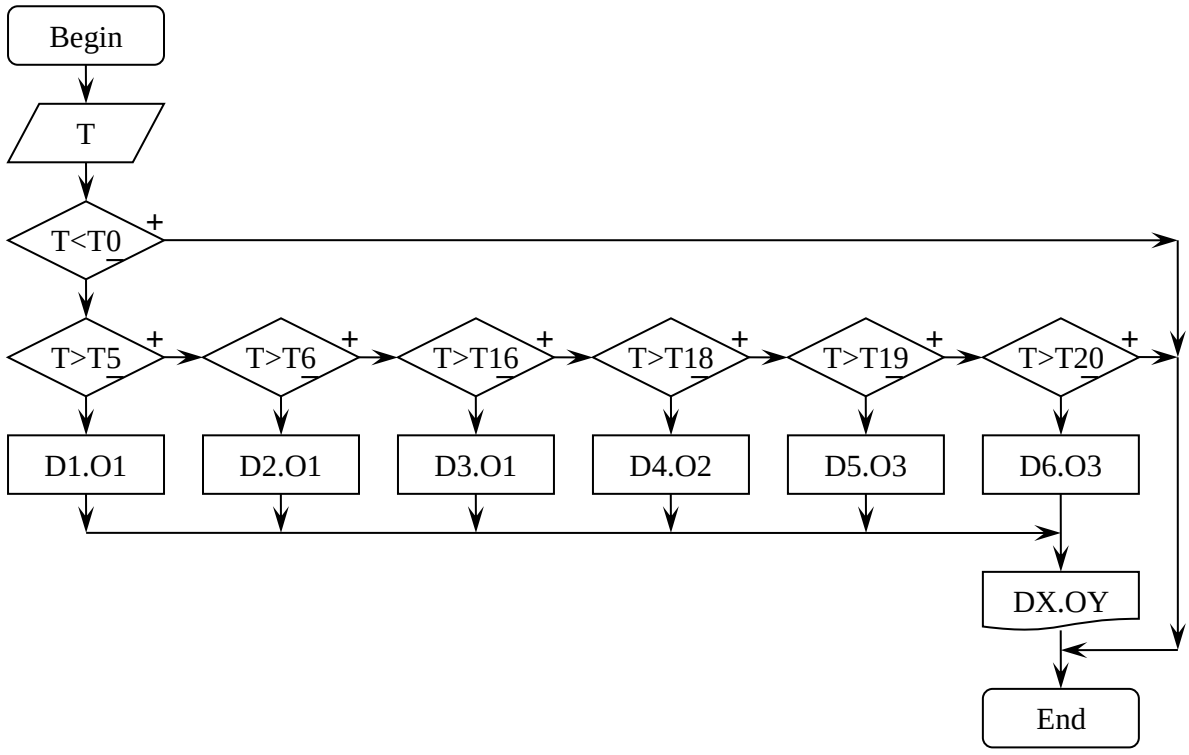

Figure 12: Block diagram of the algorithm for the sub-process of language selection

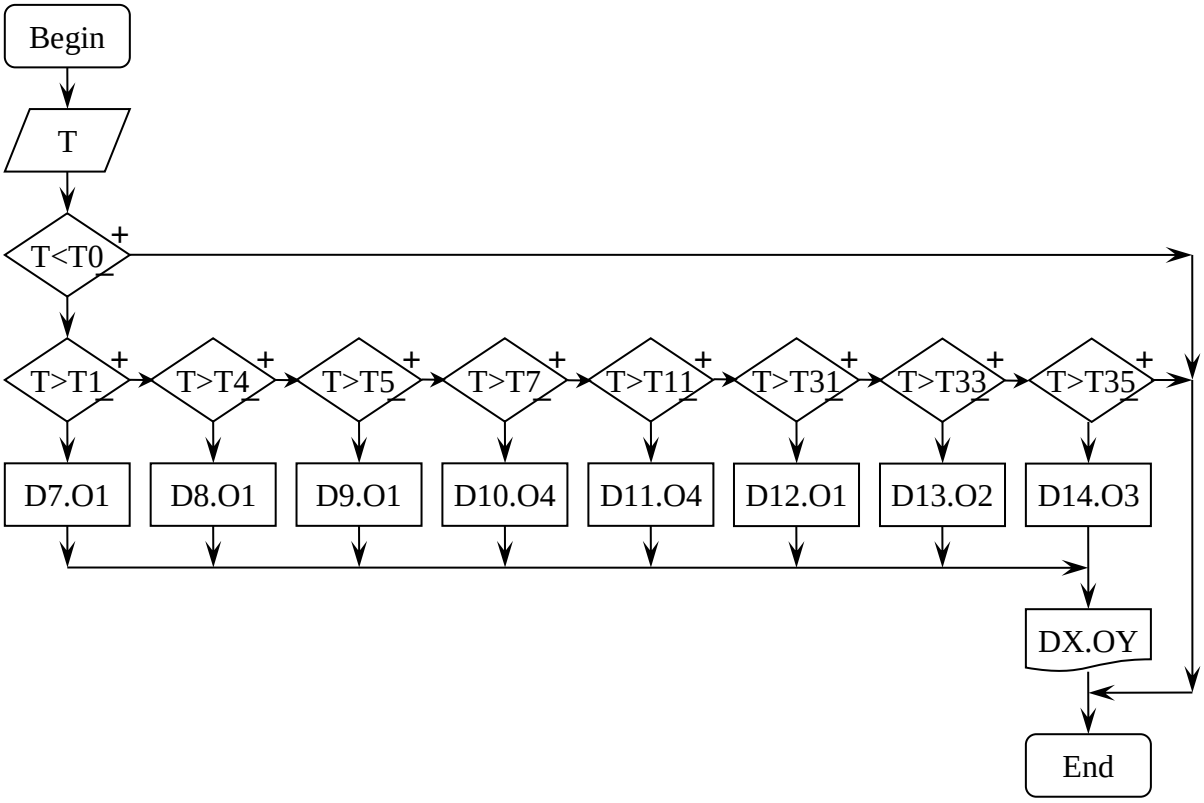

Figure 13: Block diagram of the algorithm for the payment subprocess

3.8. Results and Discussion

The process was simulated using the online environment BPSimulator, located at http://www.bpsimulator.com [16]. The following is a model built to simulate the control process (fig. 14) based on previous information models and a simulator-generated report (fig. 15). The simulation results allow to evaluate the performance of the control system software and determine the average execution time of the process [17].

Based on the simulation results, the developer is able to perform visual modeling of business processes, identify "narrow" areas of productivity, assess the time and cost of operations, select and justify the best option for organizing the management process.

4. Conclusions

Based on the developed visualization methods of processes functioning in difficult control systems the bases and methods of modeling which have allowed to display a course of processes and to carry out the management of an information system in real-time are defined. Visualization of management processes has avoided mutual misunderstandings between customers and developers of information systems, as well as reduced costs for the development, implementation, and maintenance of distributed management systems.

The goal of the project was achieved - to model the management system, as well as to develop a simplified example of models of the management system of student learning processes.

The implementation of the system allowed to optimize costs, improve the quality of services, and automate management processes, as well as improve the exchange of information between individual departments and move to an electronic management system. The introduction of changes in the system led to an increase in the competitiveness of the school, and the functionality of the system

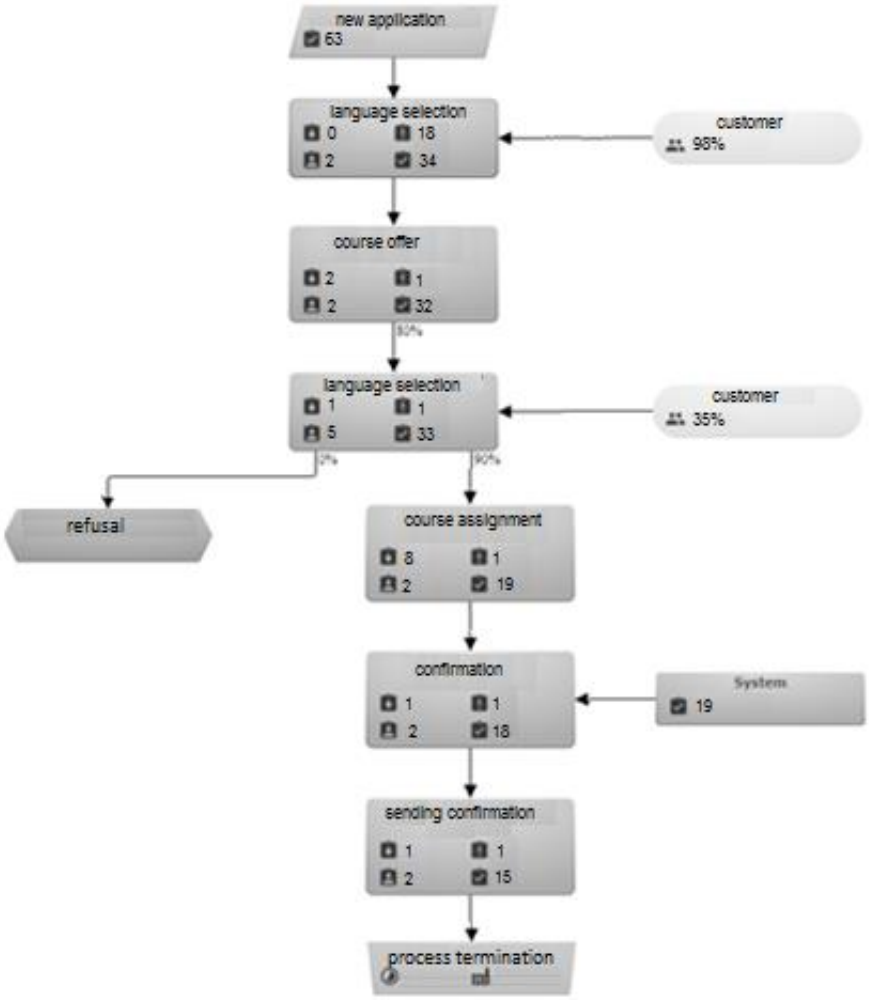

Figure 14: Block diagram of the system simulation

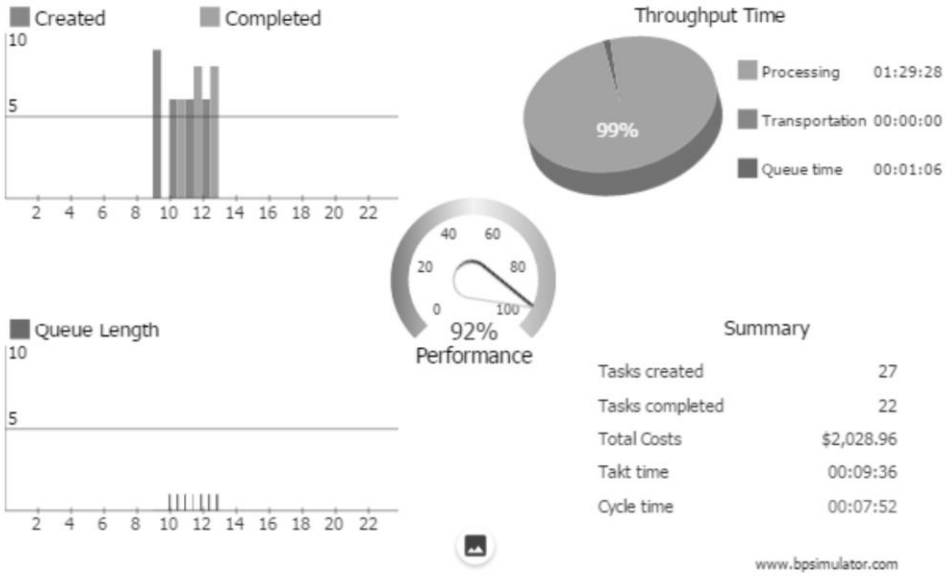

Figure 14: System load simulation report

was adapted to market standards. The implementation of the developed models is designed to create a real competition of the language school by solving the existing shortcomings of similar systems.

The economic advantage of the services offered by the language school is the scaling effect. The more students participate in the course, the more teachers provide tuition, saving money on teaching materials and teacher pay. Thanks to pre-registration for the courses, the analyst can assess the real demand for the course and hire the required number of teachers, paying in the appropriate amounts.

5. References

[1] L. Petryshyn, M. Petryshyn, W. Cieslik, Processes visualization modelling in distributed management systems, in: Proceedings of the 1st International Conference on Intellectual Systems and Information Technologies, ISIT 2019, Odessa, Ukraine, August 19-24, 2019 / ed. by Nadiia Kazakova, [et al.]. — [Odesa : CEUR], cop. 2019. — (CEUR Workshop Proceedings ; ISSN 1613-0073 ; vol. 2683). — S. [53–57].

[2] L. Petryshyn, M. Petryshyn, A. Choczynska, Management processes informative modeling at the project development stage, in: Proceedings of the 1st International workshop IT Project Management, ITPM 2020 Slavsko, Lviv region, Ukraine, February 18–20, 2020, Vol. 1 / ed. by Sergey Bushuyev [et al.], — Lviv : [CEUR Workshop], cop. 2020. — (CEUR Workshop Proceedings ; ISSN 1613-0073 ; vol. 2565). — S. 254–265.

[3] IEEE 830-1998 Recommended Practice for Software Requirements Specifications.

[4] IEEE 1233-1996 Guide for Developing of System Requirements Specifications.

[5] IEEE 1362-1998 Guide for Information Technology – System Definition – Concept of Operations (ConOps).

[6] 29148-2011 - ISO/IEC/IEEE International Standard - Systems and software engineering - Life cycle processes -Requirements engineering.

[7] ISO/IEC TR 19759:2015 Software Engineering — Guide to the software engineering body of knowledge (SWEBOK).

[8] ISO 15288 System Life Cycle Process.

[9] ISO/IEC 15504 Software Process Improvement and Capability Determination.

[10] IEEE 1498-1995 - EIA/IEEE Interim Standard for Information Technology - Software Life Cycle Processes - Software Development: Acquirer-Supplier Agreement (Issued for Trial Use).

[11] IEEE 1042-1987 (Reaff 1993), IEEE Guide to Software Configuration Management (ANSI).

[12] IEEE 1002-1987 (Reaff 1992), IEEE Standard Taxonomy for Software Engineering Standards (ANSI).

[13] IEEE 1045-1992, IEEE Standard for Software Productivity Metrics (ANSI).

[14] L. Petryshyn, Ya. Nykolajchuk, Analiticheskoe modelirovanie informacionnykh system avtomatizirovannogo upravleniia [Analytical modeling of infosystems of automated management] // in Zarządzanie organizacjami w gospodarce rynkowej: X międzynarodowa naukowa konferencja "Zarządzanie przedsiębiorstwem. Teoria i praktyka": Kraków, 22-23 listopada 2007 r. / pod red. Wiesława Waszkielewicza; — Kraków: Wydawnictwa AGH, — ISBN 978-83-7464-153-1 — S. 268–275. — Bibliogr. s. 338, Abstr. (2007).

[15] P. S. Abril, R. Plant, The patent holder's dilemma: Buy, sell, or troll?, Communications of the ACM 50 (2007) 36–44. doi:10.1145/1188913.1188915.

[16] BP Simulator, https://www.bpsimulator.com/run/, last accessed 2021/01/09.

[17] S. Cohen, W. Nutt, Y. Sagic, Deciding equivalances among conjunctive aggregate queries, J. ACM 54 (2007). doi:10.1145/1219092.1219093.