An Intelligent Cloud-based System for Conduction of an Enrollment Campaign

Hryhorii Hnatiienko [1], Oleh Ilarionov [1], Larysa Myrutenko [1], Oksana Vlasenko [1] and Snizhana Gamotska [1]

[1] *Taras Shevchenko National University of Kyiv, Volodymyrs'ka str. 64/13, Kyiv, 01601, Ukraine*

Abstract

This work is dedicated to the study of a topical issue of intellectual support of an admission campaign to higher education institutions (HEIs) of Ukraine under a full-scale invasion of the russian federation on the territory of Ukraine. The characteristics of this year's admission campaign for HEIs are described. The current problem is defined as ensuring the objective conduction of professional admission exams for the master's degree at a specific faculty of a Ukrainian state institution of higher education, in the context of a full-scale invasion. A wide range of software features is suggested to support the procedures for conducting professional admission exams. A range of options for configuring an intelligent system to ensure the successful implementation of an admission campaign using cloud technologies is described. Sources of intelligence in data processing are provided, and brief descriptions of the different types of intelligence are given. A mathematical model formalized in the class of multi-criteria optimization problems was constructed for the admission campaign. To solve these problems, the weighting factors of the criteria need to be determined. Various options for ensuring the proper conduct of professional exams, tools of communication between different groups of participants in the educational process, and assessment tools were considered. The description of cloud technologies applied during the admission campaign was given special attention. The computer experiment conducted for a specific faculty of the higher education institution to ensure the success of the 2022 admission campaign is described.

Keywords

Professional admission exams, multi-criteria problem, hyperparallelepiped of options, cloud technologies, weighting factors, communication toolkit, evaluation toolkit

1. Introduction

In the context of a full-scale invasion of Ukraine by russian troops, new challenges appear in all spheres of life in our country. In particular, the war initiated by the russian federation has significantly affected the preparation and conduct of the admission campaign (AC) for master's degree programs in higher education institutions (HEIs) in Ukraine, particularly with regard to professional entrance exams.

On the one hand, this direction is well developed and comprehensively researched [1-5]. However, the admission campaign (AC) is a complex process that involves multifaceted problems with many potential solutions. In other words, the problem of having too many options arises, which can make it difficult to make a rational and well-informed decision [6, 7].

A situation can arise where a unified solution is not feasible. The choice can be made spontaneously, in a spontaneous and arbitrary way, or it is possible to get rid of a too powerful set of choice options by structuring the problem and its formalization [8-10].

XXII International Scientific and Practical Conference "Information Technologies and Security (ITS-2022)", November 16, 2022, Kyiv, Ukraine
EMAIL: g.gna5@ukr.net (H. Hnatiienko); oilarionov@gmail.com (O. Ilarionov); myrutenko.lara@gmail.com (L. Myrutenko); vo12062007@gmail.com (O. Vlasenko); gamotskasl@gmail.com (S. Gamotska)
ORCID : 0000-0002-0465-5018 (H. Hnatiienko); 0000-0002-7435-3533 (O. Ilarionov); 0000-0003-1686-261X (L. Myrutenko); 0000-0003-1853-4249 (S. Gamotska)

This problem is exacerbated by risks, uncertainties, incomplete data, and other factors. These factors necessitate extensive research and the development of an intelligent system (IS) capable of solving multi-criteria problems. Furthermore, incorporating elements of intelligence in the solution process can bring the problem criteria closer to the optimal solution, and expand the set of admissible solutions.

2. Problem and statement of the problem

In the conditions of constant changes both in the external environment and from the side of the Ministry of Education and Science of Ukraine (MoES), additional requirements are imposed on the work of the intellectual system that is to be developed. The situation was particularly uncertain due to force majeure circumstances, as it was unknown how the general population involved in the AC would react to the tragic events in the country. Under normal circumstances, the number of entrants can be forecasted based on the demographic situation, the popularity of higher education institutions, and the conditions set by the regulator, the MoES.

In the current year, all conditions were disrupted:

- the demographic situation was unclear due to large-scale migration within the country, emigration of Ukrainian residents, and the partial occupation of some regions of Ukraine;
- the popularity of a HEI objectively did not change, but it was unknown how specific citizens would subjectively react to the events;
- the Ministry of Education and Science of Ukraine (MoES) changed the conditions of the AC in an experimental manner, including postponing deadlines, canceling the external independent assessment, and introducing a multi-subject comprehensive test;
- During the admission campaign process, the MoES issued new directives almost every week in response to external factors, with the goal of improving the admission campaign processes.

It is necessary to ensure a fair, timely, and professional selection of the best applicants for Ukrainian higher education institutions, while also ensuring the convenience of applicants and teachers, the safety of all participants in the admission campaign, and optimizing all relevant factors.

The problem of providing high-quality distance education became particularly urgent a few years ago due to mass demand. This problem has been extensively studied in a wide range of scientific research [11-15].

In the current conditions of Ukraine in 2022, this problem is further complicated:

- incompleteness, uncertainty and other non-factors;
- the risks of war are compounded by traditional, well-studied, and researched risks;
- mass migration and emigration of Ukrainians abroad, which are difficult and sometimes impossible to predict;
- new working conditions have been introduced for both higher education institutions and teachers specifically;
- there have been regular, unpredictable air alarms, power outages, and internet blackouts;
- the asynchrony of dangers in different regions of Ukraine further increases the risk of violating established procedures for conducting the admission campaign.

Given the new challenges and complications of operating higher education institutions, it is important to ensure a high-quality AC. All aspects of the AC should be formalized properly, the quality assurance problem for the AC should be structured, and the AC results should be quantified.

3. Intelligence in the automation of organizational systems

To address the problem, it is necessary to build an IS that supports the conduct of the admission campaign in HEIs. Below is an incomplete list of sources of intelligence that can contribute to the successful solution of the problem for the human-computer system.

All sources of intelligence listed in Table 1 can be utilized to study and create IS supporting processes for the admission campaign in Ukrainian higher education institutions at every stage of the campaign.

Table 1
Intelligence in the design and development of IS

Number	Source name	The essence of the source and its purpose
1	Using the intelligence of analysts and experts	Their knowledge, due to formalization and appropriate processing, is integrated into the algorithmic support of computer systems. Analysts and experts, as intellectual agents, participate: in the process of forming hypotheses, in ontological engineering, and in the evaluation and interpretation of models obtained for the subject area.
2	Expert decision-making and data processing technologies	As a separate entity that increases the intelligence of the system. Expert evaluation of alternatives, in particular its subset "Processing and convolution of partial estimates" and "Multidimensional scaling of pairwise comparison results"; simulation modeling based on semantic networks
3	Use of artificial intelligence methods	Model the biological basis of human intellectual activity (for example, using artificial neural networks)
4	Evolutionary foundations of the development of biological systems	Use, in particular, in the form of genetic algorithms
5	Basics of the logic of human thinking	Modeling using the theory of fuzzy sets and measures, as well as by organizing fuzzy inference systems
6	Results of knowledge engineering research	Used in data processing
7	Statistical methods of data analysis	Correlation, regression, dispersion, discriminant, factor, cluster, and other types of analysis

4. Criteria for evaluating the quality of the AC

The following criteria were selected as essential for conducting high-quality admission campaigns at the Faculty of Information Technologies of Taras Shevchenko Kyiv National University (FIT):

f_1 – ensuring maximum openness and awareness of society about the course of the AC;

f_2 – ensuring the confidentiality of information about applicants' personal data, composition of examination tickets, etc.;

f_3 – ensuring the anonymity of entrants, including for teachers participating in the AC;

f_4 – ensuring the assessment of applicants' knowledge is adequate;

f_5 – providing variable examination tickets to ensure equal treatment of applicants across different waves;

f_6 – ensuring the reliability of IS functioning.

Therefore, it is recommended to choose the best tools for conducting professional entrance exams for master's degree programs based on an analysis of how well they satisfy a set of criteria

$$f_i,\ i = 1,...,6. \quad (1)$$

Furthermore, the analytical function type (1) is not currently relevant to this stage of research. However, their presence and necessity are noted when identifying the main regularities for selecting the configuration of IS creation. The consideration of all six criteria (1) is necessary for a well-founded, formalized approach to ensuring a fair evaluation of entrants to HEIs.

5. Features of the introductory campaign software

There are several parameters to assess the quality of the software to support the admission campaign and to provide users with the opportunity to objectively evaluate the participants of professional tests [16, 17]. These parameters can be used in further research to help determine reasonable and appropriate options for admission campaign software. Some of these parameters are given in this paper:

p_1 – ergonomics – characterizes all aspects of user interaction with IS;

p_2 – functionality – defines the functional characteristics of IS;

p_3 – comfort - characterizes the convenience of the user interface;

p_4 – simplicity - characterizes the simplicity of the main stages of the user's work with IS;

p_5 – complexity - determines the completeness of the IS;

p_6 – functional completeness – reflects the implementation of all necessary functions in the IS;

p_7 – visibility – determines the visibility of the presentation of information necessary for comfortable work;

p_8 – ease of installation – reflects the IS installation process and any special knowledge required;

p_9 – resource intensity – characterizes the computer system resources required for the normal functioning of the IS;

p_{10} – the amount of memory required by the system for installation on a specific computer;

p_{11} – requirements for the amount of RAM that the system needs for stable operation;

p_{12} – ease of learning - characterizes the process of teaching users to use IS;

p_{13} – ease of operation - characterizes the ease of performing basic operations in the IS environment;

p_{14} – management of the educational process - determines how widely and by what means this opportunity is implemented;

p_{15} – content management – characterizes the completeness of the resources presented for managing and using educational material;

p_{16} – communicative capabilities – are determined by the available means of communication between the participants of the educational process;

p_{17} – the cost of the package - reflects the economic indicators of the IS;

p_{18} – the cost of the necessary software - reflects the cost of software required for the full operation of the IS, including the operating system, etc.;

p_{19} – communication services - defines the capabilities of the IS communication environment for providing technical support for conducting, managing and launching online sessions;

p_{20} – security - determines the degree of security of information used in IS;

p_{21} – speed of operation - reflects the speed of execution of basic operations with the help of IS;

p_{22} – stability - determines the resistance of the IS to non-standard influences such as power outages and user errors, etc.;

p_{23} – restoreability - characterizes the possibility of restoring IS and any information used within it in non-standard situations;

p_{24} – integration with other software products – characterizes the completeness of relationships with software products that are not part of IS;

p_{25} – responsiveness - reflects the ability to quickly obtain assistance during IS operation;

p_{26} – organization of knowledge assessment - characterizes the completeness of available tools in

the IS for organizing and conducting various forms of testing, as well as functional capabilities for creating test tasks, etc. [18-21];

p_{27} – archival capabilities – define the spectrum of the IS's capabilities for recording and saving online sessions.

6. Decision options

Several subsets of parameters influence the choice of a decision option:

P^1 – methods of ensuring the process of conducting AC,

P^2 – communication toolkit of all participants in the process,

P^3 – applicant evaluation tools and other parameters.

Therefore, we have a hyperparallelepiped (HP) of possible solutions:

$$p \in P,\ p = (p_1, ..., p_n), \tag{2}$$

where n is the number of parameters.

At the initial stage of research, the expert group used the scheme of sequential analysis of options to partially reduce the dimensionality of the HP parameters. Let's note that one of the ways to simplify the decision-making task is to convert the criteria into parameters and restrictions. When generating possible decision options and initializing the HP of type (2), it is important to consider that experts find it most convenient to set their evaluations on measurement scales that reflect an adequate assessment of the modeled situation to varying degrees:

- nominal;
- ordinal;
- rates;
- intervals;
- membership functions.

Different types of expertise, such as collective or individual, can be used to implement the specified methods of obtaining expert information.

Examinations can be single-round or multi-round and may or may not include feedback. Further improvement of the IS created by the authors can help to specify the methods for generating the HP (2).

7. Mathematical model of the admission campaign

The problem of determining the best configuration of decision parameters for the HEI can be formalized as a multi-criteria optimization problem (3), (2):

$$f_i(p) \to opt,\ i = 1, ..., k, \tag{3}$$

with $k = 6.$

When constructing the mathematical model, it was determined that all selected criteria should be maximized. The expert group chose not to include criteria in the set (3) that have minimized optimization directions. At the current stage of research, additional criteria are not necessary for the model.

Therefore, the mathematical model has the form (4):

$$\begin{aligned} f_1(p) &\to \max, \\ f_2(p) &\to \max, \\ f_3(p) &\to \max, \\ f_4(p) &\to \max, \\ f_5(p) &\to \max, \\ f_6(p) &\to \max. \end{aligned} \tag{4}$$

It should be noted that multi-criteria optimization models have wide possibilities for manipulating the choice [11]. Therefore, researchers should be cautious when formalizing decision-making problems in the class of multi-criteria models. Interpreting numerical results obtained in calculations requires careful attention from researchers.

To supplement the mathematical model to an acceptable form, appropriate heuristics should be applied according to the methodology of multi-criteria optimization. These may include choosing a method of normalizing the initial data, assigning or calculating weighting factors for the criteria, and implementing other heuristics.

8. Weighting coefficients of criteria

Defining a compromise solution to the multi-criteria optimization problem requires introducing additional heuristics in the form of weighting factors for the criteria. Let's briefly discuss this stage of finding a compromise. As a rule [8, 23], weighting factors of the criteria are determined in a normalized form:

$$\rho_i > 0,\ i = 1,...,6,\ \sum_{i=1}^{5} \rho_i = 1, \tag{5}$$

taking into account the fact that there are six criteria for the specific multi-criteria problem considered in this work.

Calculating (assigning, detecting, evaluating) the weighting factors significantly affects the potential for manipulation when searching for a solution [22].

At the current stage of determining a compromise solution, all experts agreed to apply the same weighting coefficients to all criteria, i.e.:

$$\rho_i = 0{,}167,\ i = 1,...,5.$$

9. Variants of ensuring the procedure for conducting professional exams and communication tools

Expert technologies are an important tool for solving the problem [24]. It is worth emphasizing that expert technologies were consistently and reasonably utilized at all stages of problem-solving:

- when building a mathematical model of conducting the AC at the faculty ;
- when choosing criteria for the quality of the AC and determining their relative weight for solving the multi-criteria optimization problem;
- when determining possible parameter values;
- when reducing the set of parameter values by applying the scheme of sequential analysis of options;
- when estimating the labor costs required by the selected system configuration.

It is also necessary to distinguish between different levels of interaction and communication between representatives of different categories of participants of the introductory campaign:

- administration, organizers, and those responsible for the introductory campaign;
- administration and heads of departments;
- heads of departments and teachers;
- members of the admissions committee and technical staff;
- members of the admissions committee and applicants.

This differentiation minimizes direct interaction between participants in the admission campaign, thereby excluding manifestations of corruption, unwanted influence between representatives of different groups of professional tests, and other subjective factors that could negatively affect the campaign's quality.

The faculty's expert group determined options for conducting professional entrance exams for the master's degree, including:

- in offline mode (personal presence of the applicant at the exam);
- online mode using faculty servers;

- online mode using separate servers by each department;
- online mode using a dedicated server in data centers of Ukraine;
- online mode using a dedicated server in data centers outside of Ukraine;
- online mode using PaaS technologies in data centers outside of Ukraine.

However, selecting communication tools for representatives of different participant categories in the AC remains an important issue. In the current conditions, among the existing communication platforms, the following have become the most popular in our HEI:

- Zoom – a program for organizing video conferences developed by Zoom Video Communications, which provides a video telephony service for remote work, distance learning and social communication using the Internet [25];
- Google Meet is a video phone communication service developed by Google [26];
- Microsoft Teams is a collaborative workspace in Office 365 from Microsoft that integrates users, content, and tools to help teams work more effectively [27, 28].

Other communication options were not considered. The expert group chose not to overcomplicate matters by selecting additional communication tools from other subject areas or using exotic software. It is clear that heavy, powerful, multifunctional document management systems were not considered for use in this admission campaign.

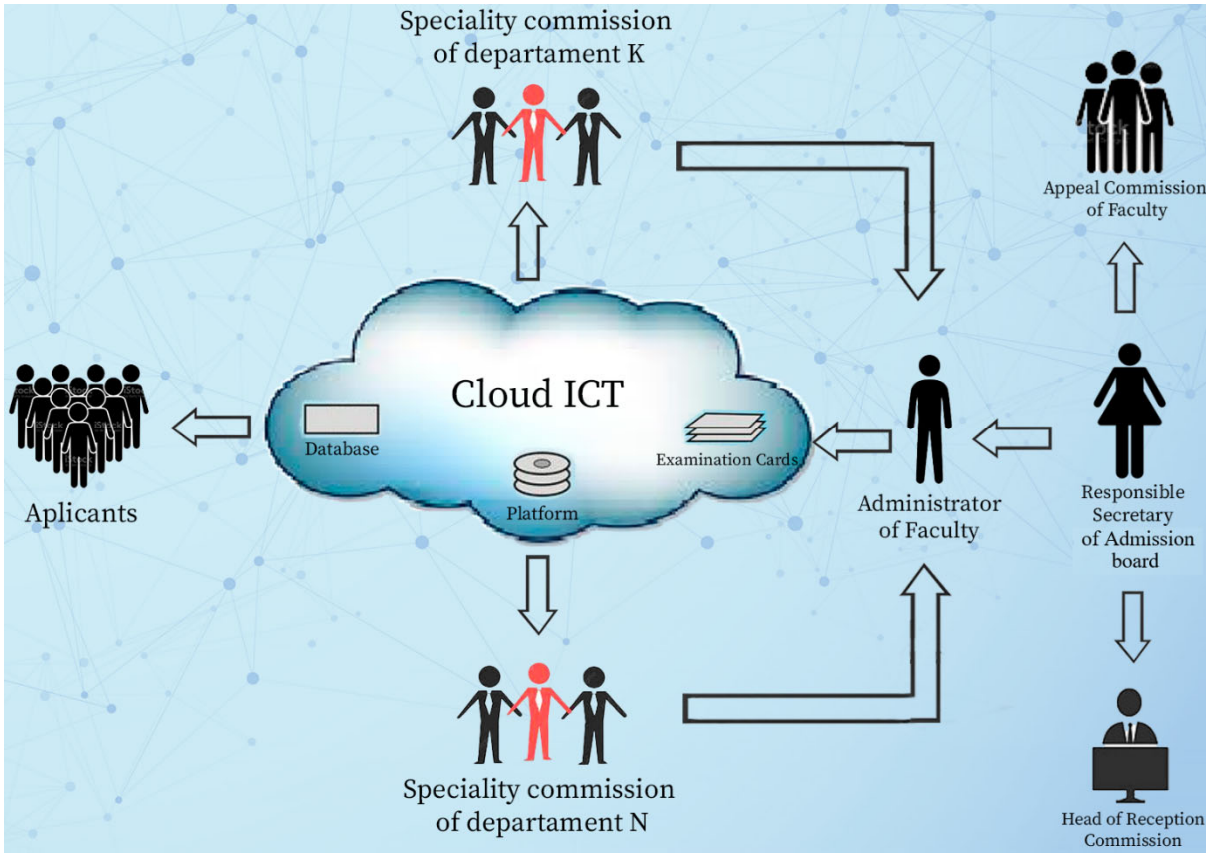

Figure 1: Structural diagram of the use of cloud technologies in the conduct of admission tests at the Faculty of Higher Education

10. Cloud technologies

To address the issue that arose during the 2022 admission campaign and its associated tasks, the expert group decided to utilize cloud technologies [29, 30]. Figure 1 illustrates the structural scheme for administering admission tests using cloud-based technologies at the faculty.

The LMS Moodle was selected as the platform for administering the admission professional test, enabling the differentiation of applicants' access by educational programs and dates within the same program. For optimal deployment and resource management, the Moodle platform is installed in the

cloud service as a Docker container image. The deployment scheme for the container image is illustrated in fig. 2 and fig.3.

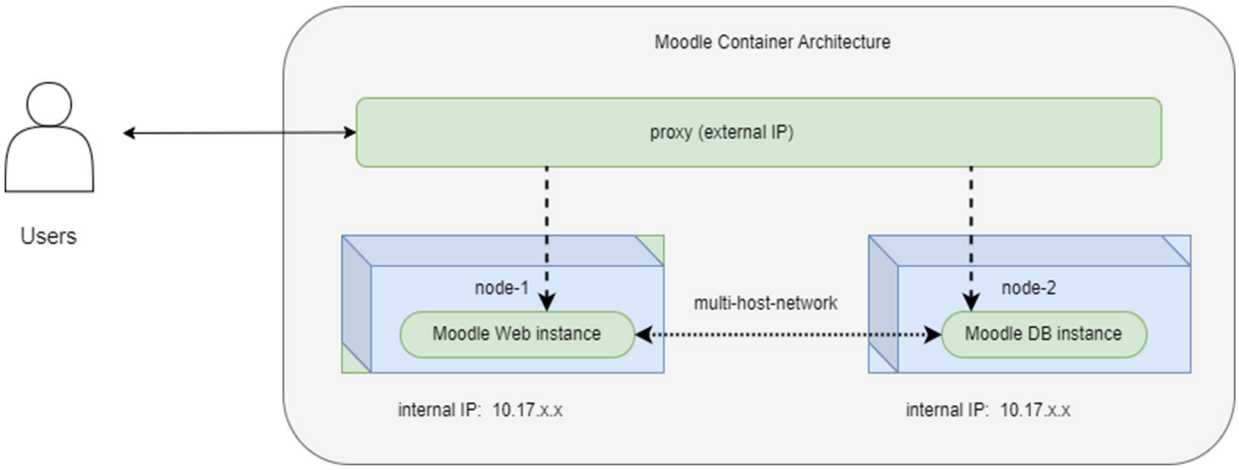

Figure 2 : Deployment of the container image

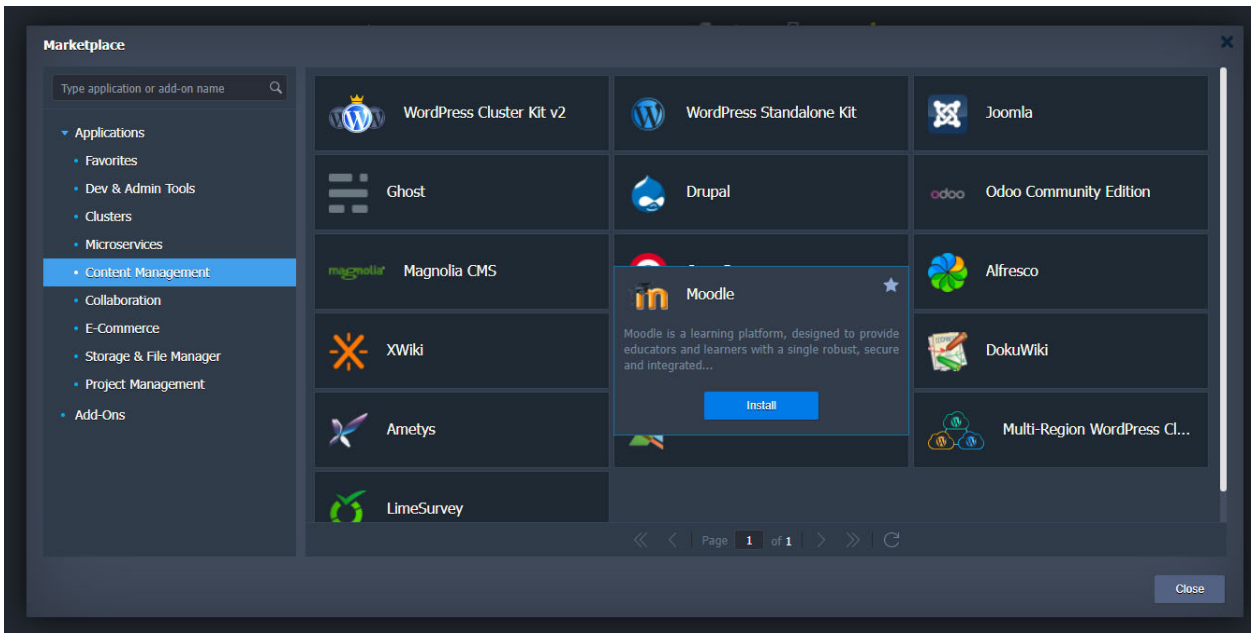

Figure 3 : Selecting a Moodle container image from the application store

Also, PaaS Jelastic allowed to optimally use the hardware resources involved in this container (Fig. 4).

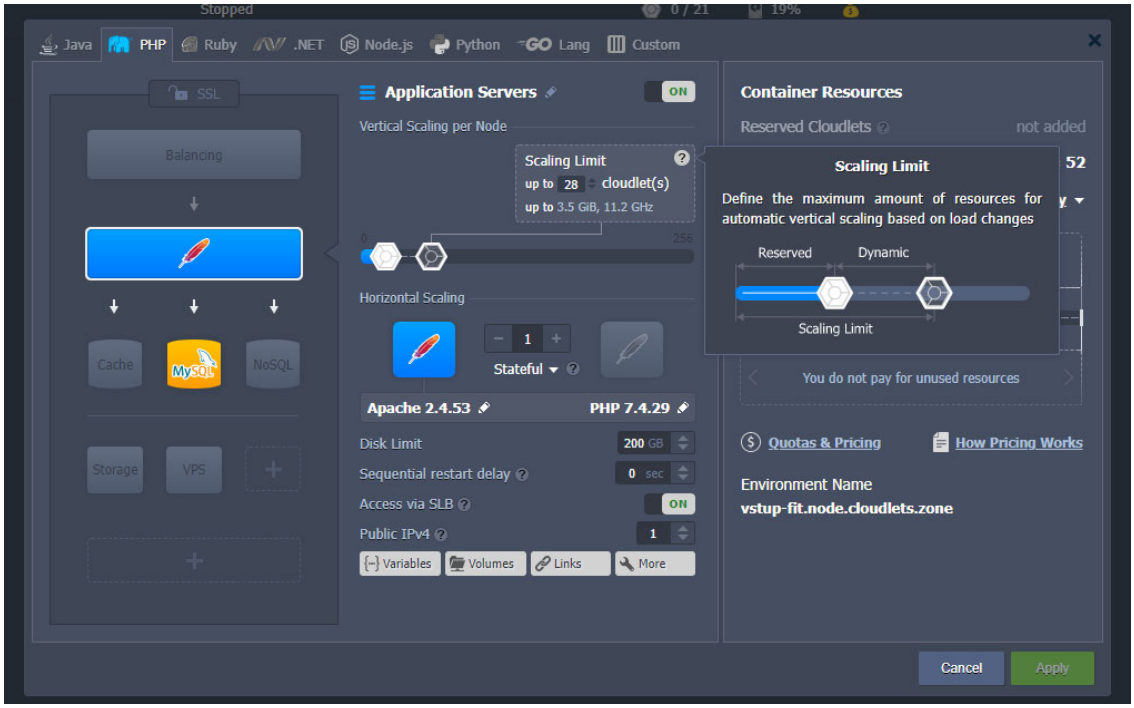

Figure 3 : The control panel of the hardware resources of the container

11.Evaluation toolkit

At the initial stages of discussion, the expert group on evaluation tools considered a wide variety of forms and means of assessment. The brainstorming method was used. Eventually, the experts narrowed down their selection to the most popular products in Ukraine, and after several rounds of meetings, the group reached a collective decision. The expert group previously selected the three most popular testing options among educators in Ukraine:

- using tools for testing the Moodle platform [31, 32];
- using Google Forms for testing;
- testing based on MS Office 365 and MS Teams.

Moodle (Modular Object-Oriented Dynamic Learning Environment) is a free, open-source system that is widely recognized as the most advanced and popular system for this purpose in Ukraine and around the world [33-40].

Google Forms is a tool used to create surveys, tests, quizzes, and web quests. One important feature of Google Forms is its ability to offer formative assessments that can be taken repeatedly to improve and consolidate knowledge. Additionally, Google Forms allows for the customization of tasks based on previous answers.

MS Office 365 and MS Teams are collaboration software designed for hybrid work, enabling testing to be organized on this platform.

12.Computational experiment

12.1. Selection of tools for assessing the knowledge of entrants

The evaluation of the quality of software support for conducting admission professional tests can be carried out both by direct assessment of criteria values and by calculating the values of criterion functions that depend on several parameters.

Currently, the type of criterion functions (4) does not need to be determined, but it is likely that discrete separable functions will need to be constructed in future research.

Expert survey was conducted for the formalized selection of knowledge assessment tools for IS. 7 experts evaluated three options (MOODLE, Google Forms, Microsoft Teams) on a 5-point scale. The results of these expert assessments are summarized in three tables - Table 2, Table 3, Table 4.

Table 2

Expert evaluations of the MOODLE system on 6 criteria on a 5-point scale

Name of experts	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6
Expert 1	4	5	5	4	5	4
Expert 2	4	5	5	5	5	4
Expert 3	5	4	5	4	5	5
Expert 4	4	5	4	4	4	4
Expert 5	5	5	5	4	5	4
Expert 6	4	5	5	4	5	5
Expert 7	4	4	5	5	4	4

Table 3

Expert evaluations of Google Forms tools according to 6 criteria in a 5-point scale

Name of experts	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6
Expert 1	5	4	5	4	4	5
Expert 2	5	4	5	5	3	4
Expert 3	4	4	5	4	4	5
Expert 4	5	5	5	5	4	4
Expert 5	5	5	4	4	3	4
Expert 6	5	4	4	5	4	5
Expert 7	4	4	5	4	3	5

Table 4

Expert evaluations of the MOODLE system on 6 criteria on a 5-point scale

Name of experts	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6
Expert 1	5	4	4	3	4	5
Expert 2	5	4	3	3	3	5
Expert 3	5	5	3	4	3	4
Expert 4	4	5	4	4	4	5
Expert 5	5	4	4	4	3	5
Expert 6	5	4	3	3	5	4
Expert 7	5	4	3	5	4	5

After that, an average score was calculated for each criterion for each option. The value of the average expert scores for each version of the assessment toolkit was summarized in Table 5.

Table 5

Average values of expert evaluations for entrant evaluation options according to 6 criteria

Name of criterion	MOODLE	Google Forms	Microsoft Teams
Criterion 1	4.29	4.71	4.86
Criterion 2	4.71	4.29	4.29
Criterion 3	4.86	4.71	3.43
Criterion 4	4.29	4.43	3.71
Criterion 5	4.71	3.57	3.71
Criterion 6	4.29	4.57	4.71

Upon analyzing Table 5, it is clear that all three options belong to the Pareto set, as the vectors of evaluations for all six criteria are non-dominated. To determine a compromise solution for this multi-criteria optimization problem, additional heuristics must be applied according to the methodology.

To convert the values of table 5 to a dimensionless form, having assessment on a scale from 1 to 5, the formula was applied:

$$\omega(x) = (5 - x) / 4,$$

where x is the average value of criteria from Table 5.

This results in Table 6, containing the values of connections for each criterion and option. Each discrepancy represents the normalized distance between the value and the optimal value, which is zero. It should be noted that the group of experts initially determined that all criteria have equal weight in solving the decision-making problem. Therefore, the gaps in Table 6 can be considered both normalized and weighted.

When solving a multi-criteria optimization problem, an additional heuristic is the statement that the compromise solution of such a problem is the one that is closest to the point of intersection of the Pareto set with the vector of weighting factors of the criteria. Such a solution is provided by the argument of the minimax criterion.

Table 6

Inconsistencies of expert evaluations for options for evaluating applicants according to 6 criteria

Name of criterion	MOODLE	Google Forms	Microsoft Teams
Criterion 1	0.18	0.07	0.04
Criterion 2	0.07	0.18	0.18
Criterion 3	0.04	0.07	0.39
Criterion 4	0.18	0.14	0.32
Criterion 5	0.07	0.36	0.32
Criterion 6	0.18	0.11	0.07
The argument of the minimax criterion	0.18	0.36	0.39
The argument of the additive criterion	0.71	0.93	1.32

According to the minimax and additive criteria, the first option, MOODLE, was the closest to the optimum. Therefore, a reasoned decision was made to select MOODLE as the toolkit for evaluating entrants during the AC, as a compromise solution to the multi-criteria optimization problem.

12.2. Selection of tools for communication between AC participants

In order to apply a formalized assessment of the options for selecting communication tools between the participants of the AC, to check the above-described mathematical model and to justify the compromise selection of tools, a computational experiment similar to the previous procedure was conducted. A group of seven experts, who were the heads of departments appointed as heads of specialist commissions during the admission campaign, was formed. At the first stage, all experts agreed that the selected criteria (4) are equivalent from the point of view of selecting a compromise solution.

In the next stage of finding a compromise solution, each expert in the created group evaluated the values of criterion functions of type (4). 7 experts evaluated three options (Zoom, Google Meet, and Microsoft Teams) on a 5-point scale. The results of this round of examination are shown in Table 7.

Table 7
Expert evaluations of Zoom on 6 criteria on a 5-point scale

Name of experts	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6
Expert 1	5	4	5	4	5	4
Expert 2	4	5	4	5	4	5
Expert 3	5	4	5	4	5	5
Expert 4	5	5	4	5	4	4
Expert 5	4	4	5	4	4	4
Expert 6	4	5	5	4	4	5
Expert 7	4	4	5	5	5	5

Thus, 7 experts rated the Zoom program on a scale from 1 to 5 points according to all 6 entered criteria. The same procedure was carried out for the other two potential communication tools during the VC.

Table 8
Expert evaluations of Google Meet according to 6 criteria on a 5-point scale

Name of experts	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6
Expert 1	5	4	4	4	4	5
Expert 2	5	5	5	5	3	4
Expert 3	4	4	5	4	4	5
Expert 4	5	5	5	5	4	4
Expert 5	5	5	4	5	4	4
Expert 6	5	4	5	4	4	4
Expert 7	4	5	4	4	3	5

Table 9
Expert evaluations of Microsoft Teams on 6 criteria on a 5-point scale

Name of experts	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6
Expert 1	5	4	4	3	4	5
Expert 2	4	4	3	4	4	5
Expert 3	5	5	3	4	3	4
Expert 4	4	5	4	4	4	5
Expert 5	5	5	4	4	3	4
Expert 6	4	4	3	3	5	4
Expert 7	5	5	4	5	4	5

To summarize the initial data, the method of average ranks was employed, resulting in the average ratings for each toolkit according to each criterion. These ratings are presented in Table 10.

Table 10
Average scores for communication tools

Name of experts	Rating of Zoom	Rating of Google Meet	Rating of Microsoft Teams
Criterion 1	4.43	4.71	4.57
Criterion 2	4.43	4.57	4.57
Criterion 3	4.71	4.57	3.57
Criterion 4	4.43	4.43	3.86
Criterion 5	4.43	3.71	3.86
Criterion 6	4.57	4.43	4.57

After normalizing the experts' point assessments, we obtain a table of five normalized expert assessments.

Table 11
Inconsistencies of expert evaluations for options of communication tools according to 6 criteria

Name of criterion	Rating of Zoom	Rating of Google Meet	Rating of Microsoft Teams
Criterion 1	0.14	0.07	0.11
Criterion 2	0.14	0.11	0.11
Criterion 3	0.07	0.11	0.36
Criterion 4	0.14	0.14	0.29
Criterion 5	0.14	0.32	0.29
Criterion 6	0.11	0.14	0.11
The argument of the minimax criterion	0.14	0.32	0.36
The argument of the additive criterion	0.75	0.89	1.25

The closest to the optimum according to the minimax and additive criteria turned out to be the first option - Zoom. Therefore, according to the results of the multi-criteria optimization problem, Zoom was selected as the winner among the means of communication. All experts agreed with the validity of this result, and as a result, Zoom was used as the communication tool for all categories of participants during the AC.

13. Conclusions

The authors structured the problem of supporting the admission campaign (AC) at the faculty level. For this, using expert technologies, the authors considered the main elements of the system, generated a hyperparallelepiped of possible parameter values, formulated and formalized the multi-criteria optimization problem of the form (4), and solved it. The Zoom platform was chosen as the main method of communication based on a formal evaluation. An expert determined that the Moodle system would ensure objective assessment. The results of the AC at FIT demonstrate the effectiveness of the AC system created by the authors.

Despite challenging circumstances, the demand for educational services at the Faculty of Information Technology has not decreased, thanks in part to a successful advertising campaign. This

year, the number of applicants to our faculty was higher than in previous years. The innovations introduced at FIT played a significant role in this year's successful AC.

Specifically, the lack of appeals from applicants and the high rates of admissions to the master's program - both in terms of the number of available slots and high objective grades on professional entrance exams - demonstrate the quality of the AC held at the faculty.

14.References

[1] S.O. Mudruk. The only professional entrance test in the context of the analysis of regulatory influences and the effectiveness of the educational service. Kyiv: Vaite Company Publishing House, 2021. 176 p. [Online]. Available: [https://www.osce.org/files/f/documents/7/c/509042.pdf.]

[2] S. Kvita (Ed.). Annual report of the National Agency for Quality Assurance of Higher Education for 2019. Kyiv: National Agency for Quality Assurance of Higher Education, 2020. 244 p.

[3] S. Kvita and O. Eremenko (Eds.). Annual report of the National Agency for Quality Assurance of Higher Education for 2020. Kyiv: National Agency for Quality Assurance of Higher Education, 2021. 364 p.

[4] I.M. Budnikevich and N.V. Romanyuk. Formation of competitive advantages of universities: marketing approach. Scientific Bulletin of Chernivtsi University. Economy. 2014; Issue 681:108-114. [Online]. Available: [http://nbuv.gov.ua/UJRN/Nvchu_ec_2014_681_23.]

[5] L.S. Vasylchenko, O.V. Kolomytseva, and L.M. Chepurda. Communication support in the formation of the regional market of educational services. Scientific notes of "Krok" University. 2019; No. 3 (55):55-62.

[6] D. Ariely. Predictably irrational: the hidden forces that shape our decisions. HarperCollins, New York, US (2008). 304 p.

[7] D. Ariely and K. Wertenbroch. Procrastination, deadlines, and performance: self-control by precommitment. Psychol Sci. 2002;13:219-224.

[8] I.M. Makarov, T.M. Vinogradskaya, A.A. Rubchinskiy, and V.V. Sokolov. Theory of choice and decision making. Moscow: Nauka, 1982. 330 p.

[9] A.F. Voloshin, G.N. Gnatienko, and E.V. Drobot. A Method of Indirect Determination of Intervals of Weight Coefficients of Parameters for Metricized Relations Between Objects. Journal of Automation and Information Sciences. 2003;35(1-4).

[10] V. Hrechko, H. Hnatienko, and T. Babenko. An intelligent model that assess information systems security level. In: 2021 Fifth World Conference he Smart Trends in Systems Security and Sustainability (WorldS4). London, United Kingdom, 29-30 July 2021. Date Added to IEEE Xplore: 19 August 2021. pp. 128-133. doi: 10.1109/WorldS451998.2021.9514019

[11] A. Biloshchytskyi, A. Kuchansky, S. Paliy, S. Biloshchytska, S. Bronin, Y. Andrashko, et al. Development of technical component of the methodology for projectvector management of educational environments. Eastern-European Journal of Enterprise Technologies. 2018;2(2 (92)):4–13. doi: 10.15587/1729-4061.2018.12.6301

[12] O.M. Pavlenko, S.V. Sharov, L.Yu. Moskalova, T.M. Sharova, and A.S. Kovalenko. Implementation of distance education using the Moodle platform in the process of training future philologists. Engineering and educational technologies. 2019;7(3):106-121.

[13] O. Tamarkina. Independent work of students of higher education institutions in the conditions of distance learning. Current issues of humanitarian sciences. Drohobych. 2020;Issue 34, Volume 5:228-231.

[14] M. Umryk. The experience of organizing students' independent work in the conditions of distance learning. Scientific journal of the NPU named after M.P. Drahomanova. Series 2. Computer-oriented learning systems. Kyiv. 2020; No. 5 (12):192-195.

[15] O.M. Spirin and K.R. Kolos, The technology of organizing mass distance learning of students in quarantine conditions based on the Moodle platform. Information Technologies and Teaching

Aids, vol. 79, no. 5, pp. 29-58, 2020. [Online]. Available: [http://nbuv.gov.ua/UJRN/ITZN_2020_79_5_5]
[16] A. Kuchansky, Y. Andrashko, A. Biloshchytskyi, E. Danchenko, O. Ilarionov, I. Vatskel, and T. Honcharenko, The method for evaluation of educational environment subjects' performance based on the calculation of volumes of simplexes. Eastern-European Journal of Enterprise Technologies, vol. 2, no. 4 (92), pp. 15-25, 2018. doi: 10.15587/1729-4061.2018.126287
[17] S.Ya. Krepych and I.Ya. Spivak (Eds.), Software Quality and Testing: A Basic Course. Study guide. Ternopil: V.A. Palanytsia FOP, 2020, 478 p.
[18] N.M. Bolyubash, Pedagogical testing in the LMS Moodle system. Information Technologies and Teaching Aids, vol. 60, no. 4, pp. 116-127, 2017. [Online]. Available: [http://nbuv.gov.ua/UJRN/ITZN_2017_60_4_12] (accessed Oct. 5, 2022).
[19] H. Hnatiienko, V. Snytyuk, N. Tmienova, and O. Voloshyn, Determining the effectiveness of scientific research of universities staff. In: Proceedings of the 7th International Conference "Information Technology and Interactions" (IT and I 2020), Kyiv, Ukraine, Dec. 2-3, 2020, pp. 164-176. CEUR Workshop Proceedings, vol. 2833. doi: 10.5281/zenodo.5758033.
[20] Y.V. Tryus, G.O. Zaspa, A. V. Ashirova, and O. S. Kozhemyakin, Information-analytical system of support for educational activities of structural units of higher education institutions. Bulletin of the Cherkasy State Technological University. Ser.: Technical Sciences, no. 4, pp. 27-38, 2020. doi: 10.24025/2306-4412.4.2020.219482
[21] H. Hnatiienko, V. Snytyuk, N. Tmienova, and O. Voloshyn, Application of expert decision-making technologies for fair evaluation in testing problems. In: Selected Papers of the XX International Scientific and Practical Conference "Information Technologies and Security" (ITS 2020), Kyiv, Ukraine, Dec. 10, 2020, pp. 46-60. CEUR Workshop Proceedings, vol. 2859. doi: 10.5281/zenodo.5741863.
[22] H. Hnatiienko, Choice Manipulation in Multicriteria Optimization Problems. In: Selected Papers of the XIX International Scientific and Practical Conference "Information Technologies and Security" (ITS 2019), 2019, pp. 234-245.
[23] V. Tsyganok, S. Kadenko, O. Andriichuk, and P. Roik, Combinatorial Method for Aggregation of Incomplete Group Judgments. In: Proceedings of 2018 IEEE First International Conference on System Analysis & Intelligent Computing (SAIC), Igor Sikorsky Kyiv Polytechnic Institute, Kyiv, Ukraine, Oct. 8-12, 2018, pp. 25-30.
[24] D. Serhan, Transitioning from face-to-face to remote learning: Students' attitudes and perceptions of using Zoom during the COVID-19 pandemic. International Journal of Technology in Education and Science (IJTES), vol. 4, no. 4, pp. 335-342, 2020.
[25] V. Kraevsky, O. Kalivoshko, N. Kiktev et al., The Role of Innovation in Economic Growth: Information and Analytical Aspect. In: 2021 IEEE 8th International Conference on Problems of Infocommunications, Science and Technology (PIC S&T), 2021.
[26] L. Luparenko, Evolution of open electronic scientific and educational systems and their use in the domestic educational space. Collection of Scientific Works of the National Academy of the State Border Service of Ukraine. Series: Pedagogical Sciences, vol. 25, no. 2, pp. 236-272, 2021. doi: 10.32453/pedzbirnyk.v25i2.775
[27] N. Herskowitz, Microsoft Teams recognized as a Leader in Gartner UCaaS and Meetings Solutions Magic Quadrants. Microsoft - Official Home Page, 2020. [Online]. Available: [https://www.microsoft.com/enus/microsoft-365/blog/2020/11/23/microsoft-teams-recognized-as-a-leader-in-gartner-ucaas-andmeetings-solutions-magic-quadrants/] (accessed Nov. 4, 2021).
[28] O.M. Khomik, N.O. Belikova, S.Ya. Indyka, and O.M. Kovalchuk, Using the Microsoft Teams platform for teaching students with disabilities. Information Technologies and Teaching Aids, no. 87 (1), pp. 306-319, 2022. doi: 10.33407/itlt.v87i1.4212
[29] T.A. Vakalyuk, Approaches to the use of cloud technologies in the educational process of a higher school in the homeland scientific literature. In: Modern Information Technologies and Innovative Teaching Methods in the Training of Specialists: Methodology, Theory, Experience, Problems, vol. 48, pp. 83-87. FOP Tarnashynskyi O.V. (2017)

[30] Yu.Yu. Dyulicheva, Implementation of cloud technologies in education: problems and prospects. In: Information Technologies in Education, vol. 14, pp. 58-64. (2013) [Online]. Available: [http://ite.kspu.edu/ru/node/1303 ?](http://ite.kspu.edu/ru/node/1303)
[31] K.P. Osadcha, V.V. Osadchiy, Distance learning technologies. Working with Moodle 2.4. Tutorial. Melitopol: Department of the MDPU named after B. Khmelnytskyi (2014)
[32] E. Zheleznyakova, I. Zmiivska: "Organization of students' independent work in the Moodle system." In: The Latest Computer Technologies. Special issue "Cloud Technologies in Education", no. 12, pp. 194-203. (2014)
[33] N. Petrovic: "Facebook vs. Moodle: What do students really think?" In: International Conference on Information Communication Technologies in Education (ICICTE), pp. 413-421 (2013)
[34] E. Zheleznyakova, I. Zmiivska, Organization of students' independent work in the Moodle system. In: The Latest Computer Technologies. Special issue "Cloud Technologies in Education", no. 12, pp. 194-203. (2014)
[35] L. DelaTorre, The ball and beam system: a case study of virtual and remote lab enhancement with Moodle. In: IEEE Transactions on Industrial Informatics, vol. 11, no. 4, pp. 934-945 (2015). doi: 10.1109/TII.2015.2443721
[36] E.A. Jackson, Impact of MOODLE platform on the pedagogy of students and staff: Cross-curricular comparison. In: Education and Information Technologies, vol. 22, no. 1, pp. 177-193 (2017). doi: 10.1007/s10639-015-9438-9
[37] A. Acar, M.N. Kayaoglu, MOODLE as a Potential Tool for Language Education under the Shadow of COVID-19. In: Eurasian Journal of Educational Research, iss. 90, pp. 67-82 (2020). [Online]. Available: [https://eric.ed.gov/?id=EJ1284359 ?](https://eric.ed.gov/?id=EJ1284359)
[38] V.I. Starosta, Moodle before, during and after the COVID-19 pandemic: use by undergraduate and graduate students. In: An Open Educational Environment of a Modern University, iss. 10, pp. 216-230 (2021). doi: 10.28925/2414-0325.2021.1018
[39] S.H.P.W. Gamage, J.R. Ayres, M.B. Behrend, A systematic review of trends in using Moodle for teaching and learning. In: International Journal of STEM Education, vol. 9 (2022). doi: 10.1186/s40594-021-00323-x
[40] L.O. Norik, Organization of the distance format of higher education based on the LMS MOODLE platform. In: Proceedings of the 4th International Scientific and Practical Conference: October 25 2022: theses add., pp. 157-160. DNU "Institute of Educational Analytics" (2022)