The automated system of models of management of information resources of higher education institution

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Abstract The special importance is gained by questions of stability of the Russian economy. Strengthening of this stability in the conditions of information revolution was resulted in need of transition from "material" to the "intellectual" economy which is based on knowledge (knowledge based economy). In this regard a problem of formation of competences of the sphere of the higher education receives a priority by preparation of the engineering and scientific shots creating the main part of profit. The article deals with the quality of service in the libraries of the university. We propose the automated system of models of management of information resource, consisting of three complexes, allowing to simulate the process of care, foresee the results of management decisions taken and choose the best of them. The complex of economic-mathematical models of quality management of service is presented in a notation of UML. Proposed economic and mathematical models for assessing the quality of decisions. The process of calculating the ratio of the qualification level of staff and the corresponding service time is shown.

1. Introduction
Nowadays the special importance is gained by questions of stability of the Russian economy. Strengthening of this stability in the conditions of information revolution was resulted in need of transition from "material" to the "intellectual" economy which is based on knowledge (knowledge based economy) [5,7,9]. It means that scientific knowledge and their carriers become a rod factor of development of production and, therefore, a key element of ensuring sustained economic growth. In this regard the special relevance is acquired by a problem of improvement of quality of management of libraries of the scientific organizations, higher education institutions. Quality management by this activity demands formalistic approach on the basis of application of economic-mathematical methods [8,13].

In this regard a problem of formation of competences of the sphere of the higher education receives a priority by preparation of the engineering and scientific shots creating the main part of profit. Considerable degree of knowledge intensity of the higher education system brings in the forefront questions of information support of scientific and educational processes which solution depends both on a condition of information resources of libraries, and on quality of the services provided by them. At the present time researches of modern domestic and foreign scientists [2-4, 6] attach great value to university libraries as to a key concept of the library activity having the specifics. These specifics consist in the multifunctionality caused by its mission to be an active component of scientific and educational process and consisting in...
assistance to accomplishment of teaching and educational process and research works, training of highly qualified specialists [10-12].

2. Methods

Modern approaches do not allow optimizing problems of quality of service of visitors in library of higher education institution. The solution of this problem is submitted by means of application of the information systems based on application of mathematical methods and developments [14].

Increase in efficiency of service of readers, aimed at reduction of queues, is one of the main tasks facing the management of libraries as loss of time of scientists has an adverse effect on efficiency of their work and slows down innovative development of our society, slows down economic growth by that.

For the purpose of increasing of this efficiency it is necessary to increase the number of the serving librarians. But, on the other hand, increasing efficiency of service, it is necessary to solve a problem of rational use of the material resources necessary for compensation of employees of library of higher education institution. Increasing the number of librarians, the problem of elimination of their idle time appears. Therefore, the choice of some compromise solution leading to increase in efficiency of service at a minimum of expenses has to be result of the solution of such problem.

Due to the fact that a part of the parameters describing process of service of readers there are random variables, the mathematical description of this process within the determined models is poor-selling. It entailed need to use a method of imitating modeling for this purpose.

Thus, as subject of modeling process of information service of readers of library of higher education institution acts. Before creation of a simulation model by the author of article the research of the input and output parameters characterizing process of information service which result is schematically presented in fig. 1 was conducted.

Herewith it is offered to consider a flow of readers W as perturbations. Output parameters are criteria of service of readers, the representing vector of \( P = \langle P_1, P_2, P_3, P_4 \rangle \), which components are: an indicator of irregularity of loading of places of service \( P_1 \), average time of stay in queues \( P_2 \), a queue length deviation from the set length \( P_3 \), the total salary \( P_4 \). As input managing variables the vector \( U = \langle U_1, U_2 \rangle \), where \( U_1 \) is quantity of points of service (number of service staff) of readers of concrete department of library, \( U_2 \) is the qualification level of librarians.

Within this article the complex of the economic-mathematical models allowing to reproduce in time process of service of readers of library of higher education institution at different variations of entrance managing \( U_1 \) and \( U_2 \) variables and also to select compromise values of the values \( U_i, i = 1,2 \) rather contradictory figures of merit \( P_i \) is given. The complex of economic-mathematical models of quality management of service is presented in a notation of UML in the form of charts of precedents (fig. 2).
Figure 2. Main diagram of precedents of a complex of economic-mathematical models of quality management of service

The UML model of a complex of economic-mathematical models of quality management of service created in a notation allows to lower significantly costs of development, modernization, modification and tuning of a program complex, and also to increase consumer quality of the software product.

Module 1 formalizing process of service of readers, in turn is presented by families of the models $M_1 = \langle M_{11}, M_{12} \rangle$, in which $M_{11}$ mathematically describes a flow of readers $W$ by means of creation of its distribution law, and $M_{12}$ uses this law reproducing process of service of readers in time. Thus, $M_{12}$ represents a simulation model which taking into account the accidental nature of perturbations of $W$ allows to receive at the exit of value of figures of merit $P_i$, $i=1,4$ at the values of managing $U_1$ and $U_2$ variables set by the researcher.

The developed system of models functions in interaction with the database in which time of arrival of readers automatically is fixed and collects, by means of processing of electronic library cards, creating a flow of requests $W$.

Therefore, the system of models $M$ reacts to change of value $W$, recalculating parameters of its distribution law. This value is received on the basis of functioning of the database which processes requirements of receiving literature by readers.

Results of functioning of the models $M_1 = \langle M_{11}, M_{12} \rangle$ are used as basic data to families of models $M_3 = \langle M_{31}, M_{32} \rangle$, making module 3 and allowing to choose a compromise solution $U^*1$ and $U^*2$ of rather contradictory criterion functions $P_i$. Search of a compromise $U^*1$ and $U^*2$ is carried out in two stages. At the first stage $M_3$ model carries out search of optimal variants of solutions $U^*1(P_i)$ and $U^*2(P_i)$, $i=1,4$ rather scalar criterion functions $P_i$ on the basis of application of a method of planning of an experiment and a method of optimization of Hook-Dzhivsa.
At the second stage M32 model of module 3 looks for compromise version of the solution of rather vector criterion function \( P=(P_1, P_2, P_3, P_4) \) with contradictory components. The model is developed on the basis of application of a mathematical apparatus of the theory of antagonistic games of Von-Neumann.

The compromise solutions recommended by a complex of M3 models made on the basis of processing of selective data allow to evaluate from the probabilistic point of view of the entrance managing variables \( U_i, i=1,2 \), where \( U_1 \) - the number of service staff of library, \( U_2 \) - their qualification level. Variable \( U_1 \) is named number of channels of service in future researches.

At any versions of the solution \( U=<U_1, U_2> \) the manager interests a question of quality of the made decisions, i.e. relative time of stay of process of service of a system is able when, for example, all channels of service are busy or free, or one is busy, and the others are free, etc. For this purpose in article are entered modules of quality of the made management decisions \( M_2=<M_{21}, M_{22}, M_{23}> \), giving the answer to these questions when using the procedure of service of readers with refusal (pattern 2), with expectation (pattern 3) and with restriction on length of turn (pattern 4).

The decision-maker – the person making a decision which is designated on the main chart of precedents is in direct interaction with a simulation model. At the same time the decision-maker changes input managing variables with the purpose to receive a compromise solution of optimization models on the basis of figures of merit which were in detail described by the author in E. D. Streltsov's article “Complex of economic-mathematical models of assessment of quality of management” (Strelcov, 2011).

At further calculation of quantity of points of service it is necessary to consider that the quantity of the financial resources going for payment of human resources has to be a constant for this organization at variation by the qualification level of personnel and should not exceed quantity of the planned means.

From this formulation the following ratio follows:

\[
U_1 \times S_i = S_i \times U_1(U_{2i})
\]

where \( U_1 \) – quantity of points of service, \( S \) - basic salary, \( U_{2i} \) – qualification level of staff of higher education institution, \( i=1,7 \).

From a ratio (1) it is easy to receive expression, for calculation of quantity of points of service with higher qualification level:

\[
U_1(U_{2i}) = U_1 \times \frac{S_i}{S_i}
\]

Let's define value of coefficient \( k_s = \frac{S_i}{S_i} = \frac{U_1}{U_1(U_{2i})} \), that is as relation of the first salary and salary with higher qualification level.

In table 1 the quantitative values of salaries accepted in the scientific and technical library of Platov South-Russian State Polytechnic University (NPI) are reduced.

**Table 1. Ratio of salaries and qualification levels in scientific and technical library of Platov South-Russian State Polytechnic University (NPI)**

| Qualification level | Si   | ks   |
|---------------------|------|------|
| 1st level           | 2650 | 1    |
| 2nd level           | 3050 | 0,868852 |
| 3rd level           | 3350 | 0,791045 |
| 4th level           | 3700 | 0,716216 |
| 5th level           | 4000 | 0,6625 |
| 6th level           | 4500 | 0,588889 |
| 7th level           | 5000 | 0,53  |
Let’s accept the following ratios:

\[ k_1 = \frac{\alpha(U_1)}{\alpha(U_1(U_{2a}))}, k_2 = \frac{\alpha(U_1)}{\alpha(U_1(U_{2a}))}; k_3 = \frac{\alpha(U_1)}{\alpha(U_1(U_{2b}))}; k_4 = \frac{\alpha(U_1)}{\alpha(U_1(U_{2b}))}; k_5 = \frac{\alpha(U_1(u_{2c}))}{\alpha(U_1(u_{2c}))} \]

Pick for \( \alpha = \frac{\lambda}{t_{op}} = \frac{t_{ar}}{t_{op}}, \) then it is possible to draw a conclusion \( k_i = \frac{\alpha(U_1)}{\alpha(U_1(U_{2c}))} = \frac{t_{op}}{t_{opt}}. \) Proceeding from the previous ratio, we will receive \( t_{opt} = \frac{t_{op}}{k_i}. \) Using the received ratio, it is possible to calculate the holding time demanded to librarian i.

The developed economic-mathematical models allow defining temporary characteristics of service of readers of library of higher education institution at various combinations of qualification levels of personnel of library. Along with the temporary characteristics received as a result of the experiments made on models in dissertation work inter-industry norms of time for the works performed in libraries are used (signed into law by the resolution the Ministry of labour of the Russian Federation of February 3, 1997 N 6). The fragment of norms of time is given in table 2, the full text is given in appendix 4.

| Norm number | Name of process, operation. Structure of work | Unit of measure | Standard time, h |
|-------------|-----------------------------------------------|-----------------|-----------------|
| 1           | Implementation of requirements of consumers, issue of documents from the main book storeroom | One reader       | 0,05            |
| 2           | Key the information about the reader: the surname, a name, a middle name characterizing it signs (education, specialty, etc.), the code | One reader       | 0,027           |
|             | To exercise control of possible availability of data on the reader who joined a public library (it is written earlier down, deprived of the right of use, etc.) | One requirement  | 0,014           |
|             | To accept the reader's requirement. To check correctness of filling of the requirement, to specify the place of storage of documents. To note in a dispatching grid, to transfer the requirement to a book storeroom | One requirement  | 0,016           |
|             | To receive requirements, to register, pick up them for codes | One requirement  | 0,03            |
|             | To find the document, to make a mark in the requirement, the book form, a dispatching grid | One requirement  | 0,048           |
|             | To establish the location of not found document on help card files, catalogs | One document     | 0,016           |
|             | To issue the document from department of a book storeroom to the consumer. To make a mark in the book form, the requirement, etc. | One document     | 0,04            |
|             | To accept the document from the consumer. | | |
|             | To find the book form, the requirement, etc. To extinguish a mark about delivery | | |
|             | Total: 0,241 h=14,46 min | | |

Using the basic data given in table 2 the maximum standard time of service is received \( t_{opt}=14 \) min.
Proceeding from it, using earlier defined ks coefficients, it is possible to time, demanded for service of readers to service staff with higher qualification level. Data are calculated and consolidated in Table 3.

Table 3. Calculated values of intermediate calculations for determination of norms of time

| U1  | Ui  | α(U1) | α(U1(U2i)) | ki   | topi |
|-----|-----|-------|------------|------|------|
| 3   | 2.606556 | 1.36  | 1.09       | 1.247706 | 11.22059 |
|     | 2.373135 | 0.818 | 1.662592 | 8.420588 |
|     | 2.148648 | 0.720 | 1.888889 | 7.411765 |
|     | 1.9875   | 0.645 | 2.108527 | 6.639706 |
|     | 1.766667 | 0.310 | 4.387097 | 3.191176 |
| 5   | 4.34426  | 3.18  | 2.34       | 1.358974 | 10.30189 |
|     | 3.955225 | 2.01  | 1.58209   | 8.849057 |
|     | 3.58108  | 1.72  | 1.848837  | 7.572327 |
|     | 3.3125   | 1.56  | 2.038462  | 6.867925 |
|     | 2.944445 | 1.1   | 2.890909  | 4.842767 |
| 7   | 6.081964 | 5.15  | 4.10       | 1.256098 | 11.14563 |
|     | 5.537315 | 3.94  | 1.307107  | 10.71068 |
|     | 5.013512 | 2.92  | 1.763699  | 7.937864 |
|     | 4.6375   | 2.75  | 1.872727  | 7.475278 |
|     | 4.122223 | 2.21  | 2.330317  | 6.007767 |
| 10  | 8.68852  | 9.09  | 6.96       | 1.306034 | 10.71947 |
|     | 7.91045  | 5.79  | 1.569948  | 8.917492 |
|     | 7.16216  | 5.23  | 1.73805   | 8.055006 |
|     | 6.625    | 4.55  | 1.997802  | 7.007701 |
|     | 5.88889  | 3.76  | 2.417553  | 5.790979 |
| 15  | 13.03278 | 13.6  | 11.4       | 1.192982 | 11.73529 |
|     | 11.86568 | 10.39 | 1.308951  | 10.69559 |
|     | 10.74324 | 8.93  | 1.522956  | 9.192647 |
|     | 9.9375   | 8.10  | 1.679012  | 8.338235 |
|     | 8.833335 | 6.92  | 1.965318  | 7.123529 |

From the system of models of assessment of quality of the made decisions for any values of intensity of arrival of readers, holding time and waiting time the author of dissertation work received assessment of quantity of points of service (U1) and holding time (top) for each qualification level (U2), these data are used as initial for a simulation model.

3. Results
1. The complex of economic-mathematical models of quality management of service presented in a notation of UML in the form of charts of precedents is developed.
2. The developed economic-mathematical models allow defining temporary characteristics of service of readers of library of higher education institution at various combinations of qualification levels of staff of library.
3. The developed tools to support of decision-making can be applied also to the solution of other important practical tasks, such as, calculation of holding time of personnel of library of higher education institution according to various qualification level.

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