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EVALUATION OF INFORMATION SYSTEMS

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The article deals with the generalized criterion evaluating the efficiency of information systems as a way to compare different systems that solve the same problem with each other. This allows to choose the most effective among them. Such a criterion must combine the partial criteria in order to counterbalance the influence of each of them on the combined generalized criterion. Well chosen generalized criterion allows to find effective innovative solutions in the construction and operation of complex systems.

Key words: *information system, generalized efficiency criterion, partial efficiency criteria, the amount of information.*

У статті розглядається узагальнений критерій оцінки ефективності інформаційних систем як засіб порівняння між собою різних систем, що вирішують одне і те саме завдання. Це дозволяє вибрати серед них найбільш ефективне. Такий критерій повинен поєднувати в собі окремі критерії таким чином, щоб урівноважити вплив кожного з них на об'єднувальний узагальнений критерій. Вдало вибраний узагальнений критерій дає можливість знаходити ефективні нестандартні рішення під час побудови і роботи складних систем.

Ключові слова: *інформаційна система, узагальнений критерій ефективності, окремий критерій ефективності, кількість інформації.*

INTRODUCTION

The concept of system is common in economics, mathematics, physics and other sciences, and a systemic approach based on this notion has shown its high efficiency [1 – 7]. However, despite the fact that the analysis of systems is covered in a large number of works, the concept of systems remains poorly understood until now. For example, enough convincing explanation of why a set of unrelated objects in their qualities is fundamentally different from the same objects that were converted into the system is missing. For example, there is no convincing explanation of why the properties of hydrogen and oxygen atoms are so strikingly different from those of water molecules formed from them. Or why the company, linked to the system, run much more efficiently than the same company, but without any mutual links.

The main feature of the systems consists in content of the elements united with links, which actually give the system new specific properties [1]. Systems often fall into one of four major classes – physical, biological, economic and social, each of which has a number of original and unique properties. However, each of these classes also has the overall system properties, which manifest themselves primarily in the integrity, divisibility and the possibility of evaluating the effectiveness of systems.

PROBLEM STATEMENT

Effectiveness of the systems is their most common characteristic, as it relates to their performance, i.e. the ability to perform useful work. In practice, the efficiency is evaluated using appropriate criteria, which are usually private for simple systems, and especially generalized for complex systems, although both of the criteria can be applied to simple and complex systems. Particular criteria are characterized by specific parameters of systems, such as speed and reliability of information or amount of profit received as a result of the system use. Generalized criteria on the other side

allow assessing the system using several partial criteria, united by one relation. Therefore, to obtain a generalized criterion of information systems, it is necessary first to determine the partial criteria, and then to find a linking relationship which is not a simple task.

Appointment of a generalized criterion is, first of all, the opportunity to compare different systems that solve the same problem with each other in order to choose the most effective among them. This criterion must combine the partial criteria in order to counterbalance the influence of each of them on the combined generalized criterion. Of course, the developement of a generalized criterion can not avoid some degree of subjectivity, as well as the analysis of the systems effectiveness using the method of peer review, but, nevertheless, such a criterion, if well chosen, allows finding creative solutions in the construction and operation of complex systems.

Today evaluating the effectiveness of implementing a variety of information technology in practice, which nowadays is vastly complicated, is considered as the task of the particular practical importance. The simplest and oldest of such systems is the transmission system, but today due to the rapid development of computer technology a host of other problems associated with the processing and transformation of information appeared apart from it [8, 9]. These include the task of optimization of production processes, coding systems, workflow, storage, archival and library information, search problems, and others [9, 10]. All of them can be implemented in the form of information systems, while each of them will have certain useful properties that are necessary to evaluate in total, which exactly allows to develope a generalized criterion of effectiveness.

The objective of this work is to develop the generalized criterion on the basis of particular criteria, which would allow evaluating the various information systems, based on the quantity, quality and speed of the transformed data. This criterion must be relatively simple to allow the possibility of its computing and provide an opportunity to make a comparison between the systems analyzed with this criterion. The latter property is known as property of systems valuation by a rate of efficiency.

SOLUTION OF THE PROBLEM

The criterion of effectiveness of information systems proposed below is based on the idea suggested in [11, 12], point of which is receiving the generalized criterion of the effectiveness of the real system on the basis of some ideal criterion that describes the best, but not real, solution of the information task of given class. Choosing the ideal criterion is based on subjective views the information system customer provides and for different systems can vary considerably, but for all that it does keep the objective prerequisites for building a real system. Typically, the customer would like the system not to make mistakes in its work, be an ideal and reliable, require no maintenance costs, transfer and process information in a maximum amount and for the minimum time achievable in the best possible information systems and cost no more than the cheapest system in its class. Performing all of these requirements in real life obviously unrealistic, but they give an idea of the ideal system which should be aimed at when designing a real system.

The amount of processed information in the information system, based on Shannon's theory, is the difference of two entropies – the maximum $H_{\max} = \ln N$, obtained in the information system after the transformation of information in which there is no loss of information, and the residual H_{res}, caused by loss of information due to noise and interference:

$$j = H_{\max} - H_{\text{res}} \geq 0, \qquad (1)$$

where N – number of initial sets (words, messages), which underwent transformation.

In the absence of noise all the initial information $j = H_{\max} = \ln N$ after the conversion is in the system in the same amount. In addition, redundant information may appear within it, which actually creates a new information structure arrays. However, in real cases the absence of noise is fundamentally impossible, and therefore it is impossible to value $j = \ln N$. This amount of converted information is possible only in a perfect information system, which should be aimed in practice. If the system also doesn't have the time loss due to correction of errors, hardware failures and other delays, it will be for the minimum average time $t_{\min}$ of arrays processing. And the maintenance costs – W_{mn}, expenditure on equipment repairs caused by failure – W_{fl} and the cost of restoring the lost information caused by noise W_{ns} will be eliminated, only minimal costs $W_{\min}$ for the purchase of hardware and software remains, which in this case are ideal. Hence, the efficiency of the ideal system would look like this:

$$E_{\text{i}} = \ln N \,/\, (W_{\min} \cdot t_{\min}) = C / W_{\min} , \tag{2}$$

where $C = \ln N / t_{\min}$ – the traffic capacity of an information system that is the system operating in the absence of interference and failures. It operates at a maximum rate of information transfer.

To obtain the rate of information transformation in a real system, the loss of information during its transformation from an initial value $\ln N$ to a real $j = H_{\max} - H_{\text{res}}$ must be taken into account, also additionally to the minimum time $t_{\min}$ of the array processing an average time of delay t_{z} must be entered as well as operating costs and expenses of unreliable information system. Then its effectiveness

$$\begin{gathered} E_{\text{r}} = (\ln N - H_{\text{res}}) / ((t_{\min} + t_{\text{z}}) \cdot (W_{\min} + W_{\text{mn}} + W_{\text{fl}} + W_{\text{ns}})) = \\ = V / (W_{\min} + W_{\text{mn}} + W_{\text{fl}} + W_{\text{ns}}) \end{gathered} , \tag{3}$$

where $V = (\ln N - H_{\text{res}}) / (t_{\min} + t_{\text{z}}) \le C$ – data conversion speed.

Ratio

$$\begin{gathered} E = E_{\text{r}} / E_{\text{i}} = V \cdot W_{\min} / (C \cdot (W_{\min} + W_{\text{mn}} + W_{\text{fl}} + W_{\text{ns}})) = \\ = (\ln N - H_{\text{res}}) \cdot t_{\min} \cdot W_{\min} / (\ln N \cdot (t_{\min} + t_{\text{z}}) \cdot (W_{\min} + W_{\text{mn}} + W_{\text{fl}} + W_{\text{ns}})) \end{gathered} \tag{4}$$

evaluates the generalized effectiveness of the real information system as a single whole. From (4) goes that the criterion proposed in the work is normed, as it varies from 0 to 1. Indeed it is equal to zero only when the residual entropy H_{res} increases to a value of $\ln N$, and equal to one when cost parameters $W_{\text{mn}} + W_{\text{fl}} + W_{\text{ns}}$ and the time t_{z} are equal to zero, that, obviously, is impossible for a real system. Normalization allows comparing various real information systems with each other and the higher is the generalized efficiency index, the more effective is the information system under analysis. It should be noted that the above criterion can be modified, since other time and cost parameters can be added to it, but its essence remains the same – it is a generalized and normalized. It is also important that the generalized criterion is dimensionless, although the effectiveness of real and ideal information systems has the dimension of bits per unit time of their conversion and the magnitude of the cost. This means that in addition to purely technical indicator – the rate of information transformation, these criteria also use economic indicators – the cost of given transformation.

CONCLUSION

Thus, the proposed generalized criterion for evaluating the effectiveness of real information systems is simple to use, estimates the cost of converting the information in the information system considering the loss of time.

The generalized criterion is a normalized and dimensionless, that makes possible to compare variety of real data conversion systems with it and, in particular, information transmission systems, that currently are most common. Considered ideal criterion of effectiveness allows real systems evaluation by comparing it with the most important parameters of the real information systems, such as the number of the transformed data, the time of its conversion and cost.

SUMMARY

ОЦЕНКА ЭФФЕКТИВНОСТИ ИНФОРМАЦИОННЫХ СИСТЕМ

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В статье рассматривается обобщенный критерий оценки эффективности информационных систем как способ сравнения между собой различных систем, решающих одну и ту же задачу. Это позволяет выбрать среди них наиболее эффективную. Такой критерий должен объединять в себе частные критерии таким образом, чтобы уравновесить влияние каждого из них на объединяющий обобщенный критерий. Удачно выбранный обобщенный критерий дает возможность находить эффективные нестандартные решения при построении и работе сложных систем.

Ключевые слова: *информационная система, обобщенный критерий эффективности, частный критерий эффективности, количество информации.*

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