certain advantages of "Impuls" in comparison of Ebilock-950, that responsible for reliability and higher unconcern of the system [2].

Conclusion. The mathematical model of research of control system is built enables in number to compare descriptions of control systems and define more optimum. Advantages of this model with the using of graphs is simplicity of the using, clearness and evidentness of results.

References

1.Tatt, U.: Teoriya grafov. Per. s angl. p. 424 M.: Mir, (1988).
2.Mathematical Models of the System Integration and Structural Unification of Specialized Railway Computer Systems //V. Moiseenko, V. Butenko, O. Golovko and other // ICTE in Transportation and Logistics 2019.– https://link.springer.com/book/10.1007%2F978-3-030-39688-6

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METHOD OF WEIGHTS DETERMINATION BASED ON RATINGS OF SOFTWARE QUALITY METRICS

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Introduction. Currently, software is as necessary as any other product that is used by humankind. Therefore, software, like other products, must have high quality.

The set of qualitative indicators of software products and methods of their determination are regulated by a number of international standards [1]-[8]. These standards are adapted in Ukraine as national. In fact, they are just a direct translation. Standards [5]-[8] do not contain the methods of software product quality indicators determination. They contain the determination methods for quality attributes only, which are indicators of the lowest level. There are no methods for determination of subcharacteristics and characteristics. In this work we used the methodic from [9] in order to improve methods from mentioned above standards.

The number of quality attributes is above two hundred. They are combined into metrics in order to make it easier the determination and the results processing. Attribute metrics are combined into subcharacteristic metrics, which are subsequently combined into characteristic metrics [5].

Quality absolute indicator $P_м$ for each metric can be expressed as follows [9]:

$$P_м = \sum_{i=1}^{n} \left(P_i \cdot V_i\right), \qquad (1)$$

where P_i – indicator of i-th subcharacteristic/characteristic; V_i – weight of i-th subcharacteristic/characteristic. Quality indicators can be determined in this manner for each hierarchical level.

International standards [5]-[8] do not explain how to get weights values. So, practical quality evaluating is significantly complicated.

The objective of this work is to develop methods for determining characteristic/subcharacteristic weights.

Method of weights determination. Documents [6]-[8] contain ratings of quality metrics H – high, M – middle, and L – low. That can be a basis for weights determination. The ratings for in-use quality metrics are presented in the Table 1 [8].

Table 1 – Ratings for in-use quality metrics

Characteristic		Rating
Name	Code	
Effectiveness	U.1	H
Productivity	U.2	H
Security	U.3	L
Satisfaction	U.4	M

The developed algorithm for weights determination works as follows.

Ratings from the Table I are pairwise compared. After that, the identity matrix is built (Table 2). The right upper part of the matrix is formed as follows [10]:

$$a_{ij} = \begin{cases} 2, i > j \\ 1, i = j \\ 0, i < j \end{cases}, \tag{2}$$

where a_{ij} – the item of right upper part of the matrix; i, j – pairwise compared ratings.

The left lower part is formed according to the following [10]:

$$a_{ji} = 2 - a_{ij}, \tag{3}$$

where a_{ji} – the item of the left lower part.

Table 2 – The matrix for weights determination for in-use quality metrics

i \ j	**U.1**	**U.2**	**U.3**	**U.4**
U.1	**1**	1	2	2
U.2	1	**1**	2	2
U.3	0	0	**1**	0
U.4	0	0	2	**1**

After that, the weights are determined as follows [10]:

$$V_i = \frac{p_i(2)}{\sum_{i=1}^{n} p_i(2)}, \tag{4}$$

where $p_i(2)$ – integrated importance of second order for i-th characteristics; n – the number of compared characteristics.

The integrated importance $p_i(2)$ can be obtained as follows [10]:

$$p_i(2) = \sum_{f=1}^{n} \left(\Psi_f \cdot p_f(1)\right); f = \overline{1,n}, \tag{5}$$

where

$$\Psi_f = \begin{cases} 2, p_f(1) < p_i(1) \\ 1, p_f(1) = p_i(1) \\ 0, p_f(1) > p_i(1) \end{cases}, \tag{6}$$

$$p_i(1) = \sum_{j=1}^{n} a_{ij}. \tag{7}$$

The correctness of the matrix can be tested using the following expression [10]:

$$\sum_{i=1}^{n} p_i(1) = n^2. \tag{8}$$

The results of the weights determination for in-use metrics are represented in the Table 3.

Table 3 – Results of the weights determination for in-use metrics

i \ j	**U.1**	**U.2**	**U.3**	**U.4**	p_i (1)	p_i (2)	V_i
U.1	1	1	2	2	6	20	0,435
U.2	1	1	2	2	6	20	0,435
U.3	0	0	1	0	1	1	0,022
U.4	0	0	2	1	3	5	0,11
Σ					16	46	1

The quality indicator of the i-th characteristic P_i can be expressed as follows [11]:

$$P_i = \sum_{k=1}^{z} \left(P_k \cdot V_k\right), \quad (9)$$

where z – the number of subcharacteristics of i-th characteristic.

Using (9), the weights vector V_k can be got as follows [11]:

$$V_k = \frac{P_k}{\sum_{k=1}^{z} P_k}. \quad (10)$$

The developed method was successfully used for the evaluation of the quality of the entropy demodulation software [12].

Conclusion. The developed determination method of quality characteristics and sub-characteristics weights improves the methods given in international standards. It makes the practical use possible for the software product quality evaluation.

References.

1.ISO/IEC 14598-2:2000 Software engineering – Product evaluation – Part 2: Planning and management. International Organization for Standardization, 2000. 11 p.J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68-73.

2.ISO/IEC 14598-3:2000 Information technology – Software product evaluation – Part 3: Process for developers. International Organization for Standardization, 2000. 14 p.

1.ISO/IEC 14598-4:1999 Software engineering – Product evaluation – Part 4: Process for acquirers. International Organization for Standardization, 1999. 32 p.

2.ISO/IEC 14598-5:1998 Information technology – Software product evaluation – Part 5: Process for evaluators. International Organization for Standardization, 1998. 25 p.

3.ISO/IEC TR 9126-1:2001 Software engineering – Product quality – Part 1: Quality model. International Organization for Standardization, 2001. 20 p.

4.ISO/IEC TR 9126-2:2003 Software engineering – Product quality – Part. 2: External metrics. International Organization for Standardization, 2003. 85 p.

5.ISO/IEC TR 9126-3:2003 Software engineering – Product quality – Part. 3: Internal metrics. International Organization for Standardization, 2003. 46 p.

6.ISO/IEC TR 9126-4:2004 Software engineering – Product quality – Part. 4: Quality in use metrics. International Organization for Standardization, 2004. 49 p.

7.M. Kuz, S. Melnychuk, and L. Zamikhovskyi, *Documentation and qualimetry of software products*, 2nd ed., Ivano-Frankivsk, 2014, 116 p.

8.S. Ivanova, "Expert method of importance weights," *Modern technologies, materials and design in construction*, V. 19, № 2, pp. 74-77.

9.M. Kuz, Ya Solovko, and V. Andreiko, "The methodic for general software quality criteria under conditions of uncertainty", *Visnyk of Vinnytsia Politechnical Institute*, issue 5, 2015, pp. 104-107.

10. M. Kozlenko and A. Bosyi, "Performance of spread spectrum system with noise shift keying using entropy demodulation," *2018 14th International Conference on Advanced Trends in Radioelecrtronics, Telecommunications and Computer Engineering (TCSET)*, Lviv-Slavske, 2018, pp. 330-333, doi: 10.1109/TCSET.2018.8336213

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MODELING OF SOFTWARE TIME CHARACTERISTICS

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Introduction. The International Standard [1] provides a nomenclature of software quality indicators, which are combined into characteristics and sub-characteristics. More than 40 of these indicators are estimates of time parameters for certain program functions performance.