Вісник Тернопільського національного технічного університету
https://doi.org/10.33108/visnyk_tntu
Scientific Journal of the Ternopil National Technical University
2023, № 1 (109) https://doi.org/10.33108/visnyk_tntu2023.01
ISSN 2522-4433. Web: ***visnyk.tntu.edu.ua***

UDC 004.4

TECHNOLOGY OF RELATIONAL DATABASE MANAGEMENT SYSTEMS PERFORMANCE EVALUATION DURING COMPUTER SYSTEMS DESIGN

Vasyl Yatsyshyn; Oleh Pastukh; Andriy Palamar; Ruslan Zharovskyi

Ternopil Ivan Puluj National Technical University, Ternopil, Ukraine

Summary. *Based on the recommendations of the international standard ISO 25010, a formalized technology for evaluating the performance of relational database management systems in the design of computer systems has been developed. Attributes and metrics of the performance characteristics were defined and elementary functions for evaluating the quality of their implementation were developed. The procedures for planning and performing evaluation processes are substantiated, which makes it possible to quantitatively express the quality of both an individual attribute and their aggregate in the form of sub-characteristics and characteristics of the external quality model. The proposed technology provides flexibility and formalizes the process of choosing the best DBMS alternatives, taking into account the type and requirements of a specific designed computer system.*
Key words: *technology, evaluation, productivity, database management system, computer system.*

https://doi.org/10.33108/visnyk_tntu2023.01.054 *Received 18.01.2023*

Statement of the problem. The design and implementation of modern computer systems requires involvement and processing of large arrays of computing information of various nature and presentation, both within the system and for the end user. This creates the need for reliable storage and ensuring the effective building of storage facilities with the possibility of receiving data and transferring or transpositioning it among software blocks of the computer system.

Taking into account the trends of development and evolution of both software and hardware development technologies, data collections are only growing [1, 2], and the search for solving the problem of their effective preservation and application leads to the appearance of heterogeneous structures, methods and tools [3], which perform the role of storage of this data. The evolution of the search for a solution to the problem of integrating data storage structures with the logical and conceptual foundations of the software that uses them has led to the emergence of a separate type of high-performance software tools, which are modern DBMSs.

Usually, customers of computer systems do not have a theoretical, technological and methodical basis for making technically correct requirements and evaluating the quality of the work performed, the effectiveness of the developed or proposed concepts [4]. This, in turn, makes it impossible to control the quality and performance of the software, does not allow to evaluate its compliance with the set requirements, and therefore there is a high probability that due to dishonest and poor-quality development, the product will not be able to perform the necessary functions and provide planned services.

Evaluation of quality, including productivity, as one of the characteristics of quality, is primarily the task of information technology experts. In their work, experts are guided by recommendations of international standards, which often offer a general concept for evaluating properties implemented in software products, and evaluation procedures are not formalized and ambiguous for different classes of software [4]. Therefore, it is relevant today to study the

 Corresponding author: Vasyl Yatsyshyn; e-mail: vyatcyshyn@gmail.com

quality of modern relational database management systems, in particular, their performance when implemented in computer systems. This involves the justification and formalization of the performance evaluation procedure, the definition of relevant quality attributes and metrics, as well as evaluation functions and scales.

Evaluation of the latest researches and publications. Taking into account that software is an important component of both computer and Information Systems, the latter (IS) forming grounds for operation of business systems, so the quality of decision making within business systems directly depends on software quality and data which are operated by the system. The importance of the software quality assurance process is also due to the presence of a variety of technologies that make it possible to design and implement systems in various ways. However, this raises a problem related to the objectivity and adequacy of quality assurance methods at stages of the life cycle and assessing the appropriateness of the attributes of the final software product. This is explained by the use by developers of their corporate technology and quality assessment criteria, which are often inconsistent and not standardized.

Thus, I. Sommerville, the author of many works [5–7] in the field of software engineering, made significant efforts to standardize processes related to the control and management of the quality of software systems. In [6], the authors analyzed a set of technologies, procedures and means of software implementation, conducted their analytical comparison and showed the importance and relevance of the problem of quality assurance and assessment in the overall design process. In [7], it is proposed to use the recommendations of the ISO/IEC 9126 (ISO/IEC 25010) series of standards for the evaluation and management of PS quality, however, they do not contain practical recommendations for the formalization of quality models, requirements development procedures, their communication, and the development of appropriate CASE tools. The absence of a formalized requirement communication procedure may result in the loss of connection between the relevant requirements and their transformations at different stages of development, which can lead to a significant deterioration in quality.

In practice, developers use organizational and technological measures to ensure software quality. Organizational measures for quality control and assurance are based on the use of human resources to monitor project development processes. At the same time, code inspection and review, testing, and a number of other measures are expected [9]. However, this approach requires significant labor and economic costs, and the results of using such measures do not always adequately reflect the real state of PS quality.

In the first works on the development of methods for assessing the quality of a PS, a method for determining the properties of a PS and establishing the corresponding metrics with the help of formal operators was proposed. However, evaluating the quality of the finished software product makes it possible to identify only needs which have not been met or partially met in the PS. At the same time, recommendations for improving quality are not always objective, since the criteria used for evaluation were subjective and not generally accepted. In addition, the impact of one quality criterion on others was not investigated. In some cases, the improvement of one indicator led to the deterioration of another one or ones. The approach [8] was based on the use of a set of unstructured quality characteristics, on the basis of which it is difficult to adequately and quantitatively assess the quality of PS, however, the appearance of such an approach gave impetus to the development and improvement of methods for ensuring and evaluating the quality of PS.

Works [10, 11] deals with methods and models of PS quality assurance from the standpoint of reliability. The method proposed by the author is based on the recommendations of the ISO 9126-1 standard. However, it should be noted that the procedure for applying the method of ensuring reliability, as one of the characteristics of the quality of PS, is quite difficult to implement in practice. This is due to the fact that the methods focused on identifying and predicting defects in the relevant processes during the development of a software project are based on merely one of the quality models of the ISO 9126 standard.

Research objective is to justify the technology of evaluating the performance of relational database management systems by using the recommendations of international standards of the ISO 25000 series [12] and to determine the attributes, metrics and functions for evaluating the performance of the class of software related to database management systems.

Introduction to the task and formalization of the DBMS productivity evaluation procedure. In general, to evaluate the productivity of modern relational database management systems, it is suggested to apply the approach proposed in [4] for evaluating the quality of software on the web. However, the external quality model needs to be transformed with an emphasis on the characteristics and attributes specific to the description of DBMS performance. The DBMS external quality model with defined sub-characteristics of the performance (efficiency) characteristic is shown in Fig. 1.

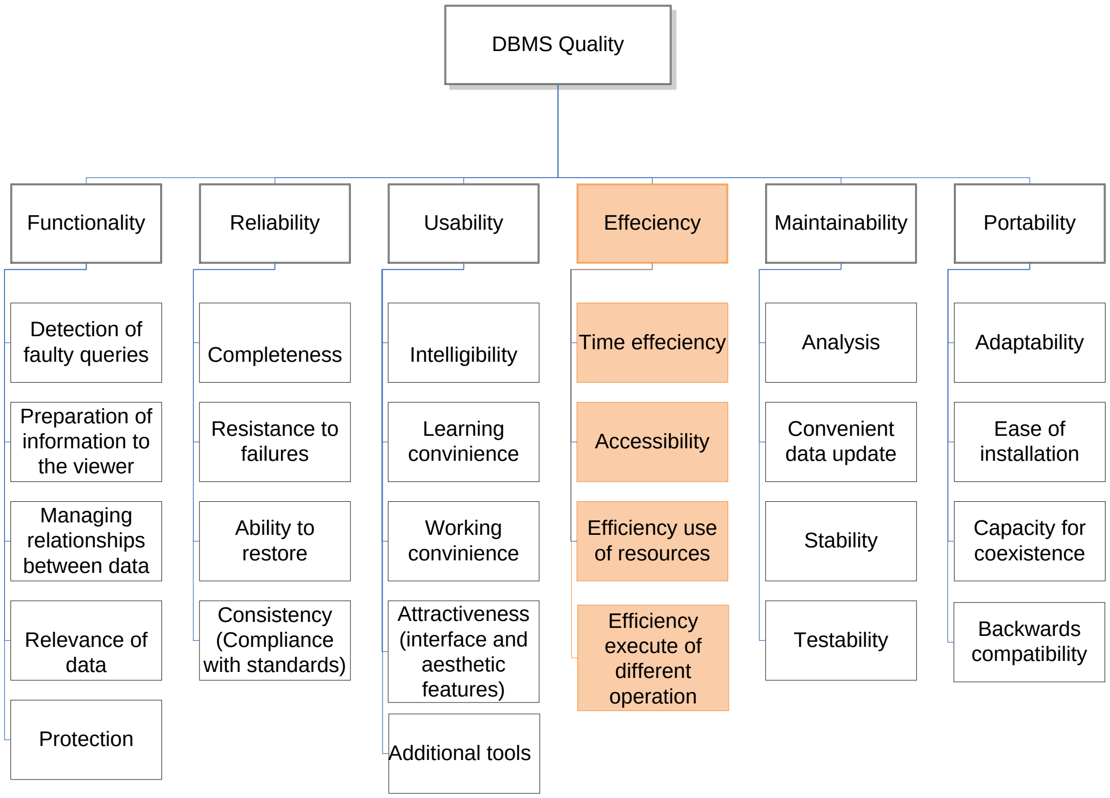

Figure 1. DBMS quality evaluation model

Modern relational DBMS productivity evaluation should rely on specific set of criteria which reflect the quality of DBMS. Making specific decisions regarding the use of certain DBMS should be well grounded, i.e. represented in the form of certain metrics with numerical interpretation.

At the same time, the productivity criteria should allow to flexibly and dynamically adjust the assessment model to meet specific expertise tasks. It can be extremely effective to differentiate the requirements according to the intended purpose of both evaluation and evaluated means, according to the goal the experts should reach, a specific case of DBMS application, and the requirements the entire computer system should follow. Therefore, the technology for evaluating the productivity of database management systems must define specific groups of attributes, the metrics by which they are determined, and their mapping to specific systems which often perform disparate and heterogeneous tasks.

Domain features, structural elements of the external quality model, customer and user needs should be presented in the hierarchy of quality requirements (Fig. 2).

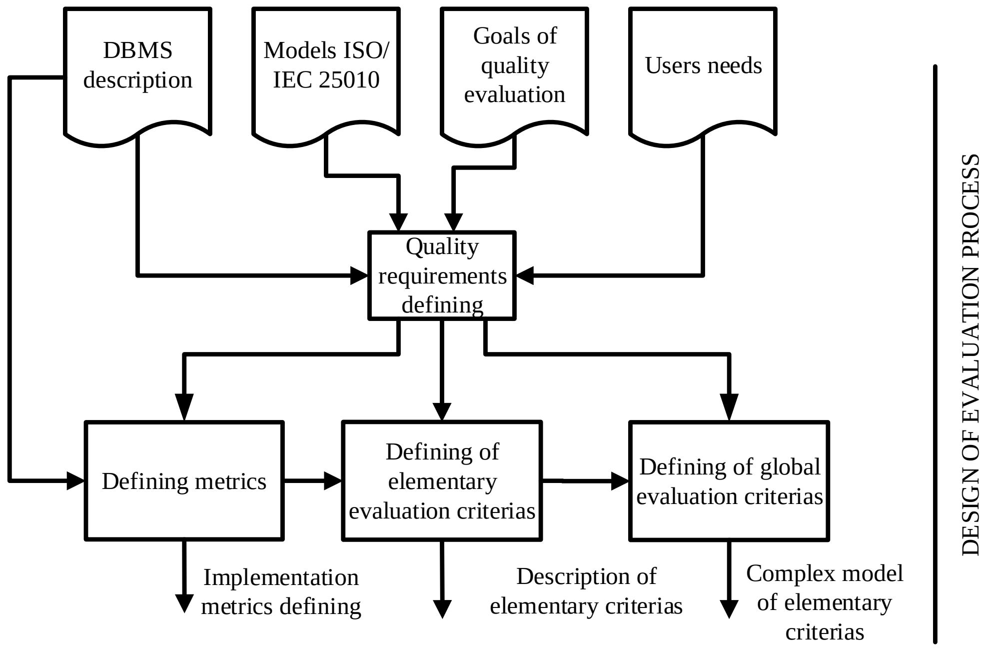

Figure 2. The process of design as a part of DBMS quality evaluation process

To ensure the adequacy and objectivity of the DBMS performance evaluation process, first of all, it is necessary to define the attributes and their corresponding metrics, as well as to propose elementary evaluation criteria. A set of elementary indicators that describe the same entity form partial or integral indicators. The process of direct quality assessment consists of three phases: measurement of implementation indicators, linearizable assessment and partial or integral assessment (Fig. 3).

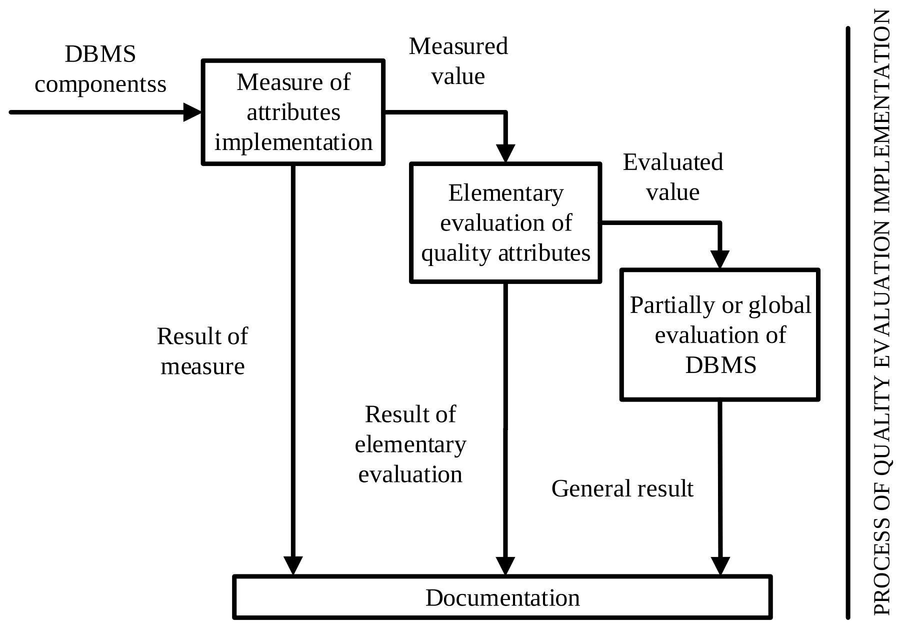

Figure 3. The process of implementation for quality evaluation of DBMS

Quantitative measurement of the quality of DBMS is performed taking into account the attributes that are defined during the design of the quality assessment. At the same time, both automated tools and methods and ways of involving manual acquisition of quantitative criteria values can be used. The type of attribute and the availability of quality expert resources are the determining factors for the use of automated tools or manual tools.

Obtaining a quantitative value of the realization of the quality of a specific attribute is not sufficient to form a conclusion about the satisfaction of quality requirements. Therefore, it is proposed to perform the approximation of attribute metrics on a fuzzy scale with defined relative ranges of quality levels. The procedure of displaying metrics on a scale is performed at the stage of forming elementary estimates of quality indicators (Fig. 3.)

In order to obtain an integral assessment of the DBMS productivity by a specific sub-characteristic or their combination, it is necessary to take into account the importance of each of the productivity attributes. This procedure is provided at the stage of partial or integral assessment.

At the stage of evaluating the productivity attributes, it is necessary to provide a quantitative measurement of the value of the implementation of the requirement and assess the level of its compliance. Any quantifiable attribute A_i can be matched with a variable X_i, which will provide a quantitative value from a direct or indirect metric. However, this measure does not show the level of compliance with productivity requirements. Therefore, it is necessary to propose such an elementary function, which would allow directly assessing the level of satisfaction of requirements with the possibility of manipulating the value of its measure. Depending on the class and the context of the requirement, one or another elementary function is used.

As an example, let's define an attribute that reflects the requirement for the speed of inserting (recording) data into the database. Taking into account the purpose of the attribute, an indirect metric of the following type can be applied to obtain its quantitative value:

$$X = \frac{number\ of\ lines}{recording\ time} \quad (1)$$

After carrying out the calculation according to (1), the average value of the data recording speed is determined. However, there is a problem with the interpretation of this value and establishing the degree of compliance with the requirements for the DBMS and the computer system. One of the ways to solve this problem is to set an elementary metric evaluation function:

$$g(X) = \begin{cases} 1,\ provided\ X \to 0 \\ \frac{X_{max}-X}{X_{max}}, provided\ 0 \le X \le X_{max}, \\ 0, otherwise \end{cases} \quad (2)$$

where $g(X)$ – elementary function;
X – metrics;
X_{max} – confirmed upper level for requirement compliance.

The use of elementary evaluation functions makes it possible to form a quantitative representation of the quality of the relevant attributes in relative units. It is also important to carry out normalization procedures of scales and metrics [14]. In order to ensure the objectivity of the evaluation process, three ranges of acceptability can be distinguished on the scale:

from 0% to 39% – unacceptability range;

– 40% – 59% – marginally acceptable range;

– 60% – 100% – acceptable range.

In addition, for greater informativeness of the quantitative value, which takes into account the quality of implementation of the DBMS attribute, you can use the acceptability coefficient. In this case, the quality assessment can be calculated by the formula:

$$q(X) = g(X) * A, \quad (3)$$

where $q(X)$ – quality indicator at the attribute level;
A – acceptance factor set by the expert for a specific attribute.

The interpretation of the acceptability coefficient is to express the quality, importance and convenience of the assessed attribute from the expert's point of view. The scope of determining the acceptance factor belongs to the interval [0;1].

At the stage of partial or integral evaluation of DBMS performance, an aggregate scheme of unification of all productivity indicators determined in the previous phase is implemented. To ensure the comprehensibility, accuracy and structure of the DBMS evaluation process at the stage of its design, it is advisable to use models and connecting criteria.

In the case when the integral performance evaluation procedure is based on a linear additive model, the partial or integral performance of the DBMS can be calculated by the formula:

$$Q = \sum_{i=1}^{N} q_i(X) * k_i, \quad (4)$$

where Q – complex productivity indicator;
k_i – attribute weight criterion;
N – number of attributes.

The weight factor k is a coefficient that reflects the importance of each specific attribute in the constructed quality model depending on the domain. The process of ranking quality attributes for a specific domain necessarily involves the use of the importance criterion [9]. Thus, a method and procedure for evaluating the performance of DBMS is proposed, which together form an evaluation technology, the input data for which are the corresponding requirements presented in the form of quality models [13].

Formation and analysis of productivity evaluation results of relational databases. He assessment model will be complete and relevant only when the characteristics and sub-characteristics for quality assessment reflect specific attributes. As a result of such mapping, the attributes that are available as quantitative measurements will be realistically compared and contrasted. Let's highlight the attributes that will correspond to the sub-characteristics of the quality model for evaluating the DBMS performance characteristics (Fig. 4).

The nature of presenting attributes in terms of metrics and methods of their evaluation is important. Descriptive nature is inappropriate, as it does not provide clarity and standardization of presentation, may contain inaccuracies or be interpreted incorrectly. One of the effective and natural views for presenting the attributes of the quality model is the tabular view. An example of the description of the «Speed of inserting data» attribute is given in the table. 1.

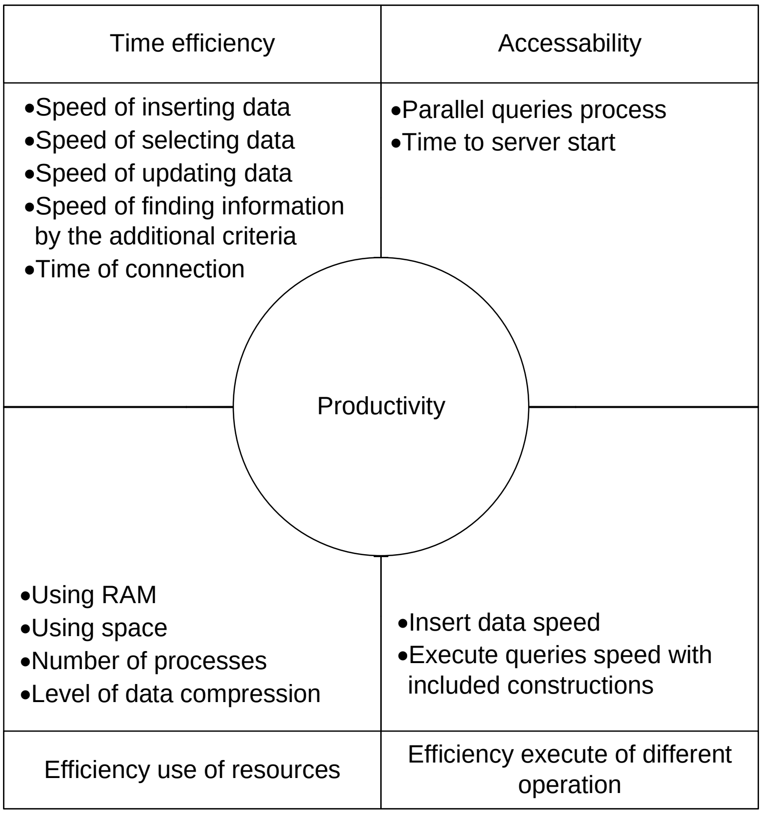

Figure 4. Subcharacteristics and attributes of characteristic«Productivity»

Table 1

Description of «Speed of inserting» attribute

Characteristic	**Productivity**
Subcharacteristic	**Time efficiency**
Attribite name	**Speed of inserting data**
Attribute definition	Inserting data is one of the main operations with data inside databases, which aims to create tuples of tables and save the given values inside them
Objective/Motivation	Data insertion should be fast, both for single and mass data transfer. Especially important is the process of building the logic of executing an insert request, using indexes, optimization taking into account relationships between tables (primary and internal keys). Insertion of data can be done directly by an SQL query or by calling a stored procedure. Both of these methods should be equally fast, but for use from software tools, it is recommended to insert data by calling stored procedures and using the transactional mechanism
Measurement scale	Relative (number of records per time unit)
Determination procedure, protocol, X	The value of the attribute can be obtained experimentally by sequentially inserting the prepared data and measuring the time. The value of the attribute is calculated as the ratio of the number of records to the time of their insertion
	Notes
Type of data collection and counting	Manual, with the help of devices, automated
Interpretation of the value of the assessment	The higher, the better

In order to quantify the attributes of the Performance characteristic, it is necessary to justify the metrics for measuring the attributes, obtain the input data for evaluation, and develop elementary functions for evaluating the attributes.

To evaluate the attributes of the «Time efficiency» sub-characteristics, evaluation metrics and elementary functions were developed, which are partially shown in Table 2 and Table 3.

Table 2

Metrics and elementary evaluation functions of data inserting and selection

Subcharacteristics	Attribute	Metrics	Elementary attribute quality evaluation function
Time efficiency	Speed of data inserting	Average speed of inserting data $X = \frac{\sum_{i=1}^{K} \frac{N_i}{t_i}}{K}$, where N_i – number of records of 1st iteration, t_i – inserting time of 1st iteration, ($ti=tstart-tend$, $tstart$ – insertion start time, t_{end} – insertion end time) K – number of insertion iterations	$g(X) = \begin{cases} 1, & \text{if } X \to X_{max} \\ \frac{X}{X_{max}}, & \text{if } 0 \leq X \leq X_{max} \\ 0, & \text{otherwise} \end{cases}$ where $X_{\max}$ – the largest maximum value for an attribute given by an expert for a specific subject area
	Data sampling rate	Average Data sampling rate $X = \frac{\sum_{i=1}^{K} \frac{N_i}{t_i}}{K}$, where N_i – number of records of 1st iteration, t_i – sampling rate of 1st iteration, ($t=t_{start}$ - t_{end}, where t_{start} – sampling start time, t_{end} – sampling end time), K – number of sample iterations	$g(X) = \begin{cases} 1, & \text{if } X \to X_{max} \\ \frac{X}{X_{max}}, & \text{if } 0 \leq X \leq X_{max} \\ 0, & \text{otherwise} \end{cases}$ where $X_{\max}$ – the largest maximum value for an attribute given by an expert for a specific subject area

Table 3

Metrics and elementary evaluation functions of data updating, searching and time of server connection to data base

Subcharacteristics	Attribute	Metrics	Elementary attribute quality evaluation function
Time efficiency	Data refresh rate	Average data refresh rate $X = \frac{\sum_{i=1}^{K} \frac{N_i}{t_i}}{K}$, where N_i – number of records of 1st refresh iteration, t_i – refresh time of 1st iteration, ($t=t_{start}-t_{end}$, where t_{start} – sampling start time, t_{end} – sampling end time) K – number of data refresh iterations	$g(X) = \begin{cases} 1, & \text{if } X \to X_{max} \\ \frac{X}{X_{max}}, & \text{if } 0 \leq X \leq X_{max} \\ 0, & \text{otherwise} \end{cases}$ where $X_{\max}$ – the largest maximum value for an attribute given by an expert for a specific subject area
	Rate of information search by additional search criteria	Search rate by advanced criteria $X = \frac{\sum_{i=1}^{K} N_i}{K}$, where N_i – number of records, which corresponds to the 1st criteria, K – number of criteria, t – search time according to the specified criteria ($t=t_{start}-t_{end}$, t_{start} – search start time , t_{end} – search end time)	$g(X) = \begin{cases} 1, & \text{if } X \to X_{max} \\ \frac{X}{X_{max}}, & \text{if } 0 \leq X \leq X_{max} \\ 0, & \text{otherwise} \end{cases}$ where $X_{\max}$ – the largest maximum value for an attribute given by an expert for a specific subject area
	Connection time	Server response time $X=t$, where t – time to establish a connection with the serve	$g(X) = \begin{cases} 1, & \text{if } X \to 0 \\ \frac{X}{t_{max}}, & \text{if } \frac{t_{max}}{2} \leq X \leq t_{max}, \\ 0, & \text{otherwise} \end{cases}$ where $t_{\max}$ – allowance time to establish connection with the server (usually 1sec)

In table 4 the values of columns «Interation range», «Oracle 11g, inserting time, msec», «MS SQL Server, inserting time, msec» were obtained by executing the same SQL-queries with the same data. The values of the «Oracle 11g, (Iteration/Time)» and «MS SQL Server, (Iteration/Time)» columns are calculated by the formula $\frac{N}{t}$, where N – iteration range, t – inserting (data resording) time. The normalized value is obtained by dividing the obtained values by the digit of the number (10000000).

Table 4

Average speed of data inserting in DBMS Oracle and MS SQL Server

Iteration range	Oracle 11g, inserting time, msec	MS SQL Server, inserting time, msec	Oracle 11g, (Iteration/Time)	MS SQL Server, (Iteration/Time)
1000	0,003	0,009	333333,33	111111,11
2000	0,02	0,007	100000,00	285714,29
3000	0,02	0,008	150000,00	375000,00
4000	0,01	0,009	400000,00	444444,44
5000	0,004	0,007	1250000,00	714285,71
6000	0,005	0,012	1200000,00	500000,00
7000	0,02	0,01	350000,00	700000,00
8000	0,006	0,014	1333333,33	571428,57
9000	0,004	0,007	2250000,00	1285714,29
10000	0,009	0,008	1111111,11	1250000,00
Sum (Iteration/Range)			8477777,78	6237698,41
The normalized quality value of the attribute			0,85	0,62
The quality value of the attribute in percentage, %			85%	62%

For a comprehensive assessment of the quality of the «Time performance» sub-characteristic, we will use formula (4). At the same time, we will take the values of the acceptability coefficient and the priority coefficient equal to 1, since these attributes are important from the point of view of productivity. The value of the quality of the attributes according to the sub-characteristic «Time efficiency» is given in the table. 5.

Table 5

Values of quality attributes by characteristic «Time efficiency»

Attribute	Relative attribute quality values	
	Oracle 11g	MS SQL Server
Data inserting time	0,85	0,62
Data sampling rate	0,97	0,99
Data refresh rate	0,71	0,91
Data search rate by advanced criteria	0,84	0,98
Server connection time	0,93	0,89
Total indicator	4,3	4,39
The normalized value of the total quality indicator according to the «Time efficiency» characteristic	0,86	0,88
The quality value of the sub-characteristic «Time efficiency» in percent, %	86%	88%

Thus, by applying the proposed method of evaluating DBMS performance, the quality value of the «Time efficiency» sub-characteristic was obtained. By analogy, the quality of other sub-characteristics of the «Productivity» characteristic was calculated and a complex indicator of the quality of relational DBMS productivity was determined.

Research findings. As a result of the research conducted, the contemporary state of development of relational database management systems, the possibility and expediency of their use in the design and implementation of computer systems have been determined. The expediency of developing and implementing formal methods and procedures for evaluating DBMS quality when choosing alternative solutions, based on the use of the recommendations of the international standard ISO 25010, is substantiated.

The paper proposes a technology for evaluating the productivity of relational DBMSs, which uses the method proposed in [4], taking into account the features of the class of software to which DBMSs belong. The developed technology for evaluating DBMS productivity, as components of a comprehensive quality characteristic, is based on the attributes and metrics defined and proposed by the authors. Thanks to the attribute quality evaluation functions developed in the work, a scientifically based and practically oriented approach to the formation of a set of quantitatively expressed attribute quality values of specific DBMSs is provided. This makes possible to increase the efficiency of decision-making when choosing the best alternatives for data storage and management in the process of designing computer systems.

The proposed method for evaluating the performance of relational DBMS involves the implementation of local, partial and integral quality evaluation procedures, which allows determining the priorities of attributes at different levels. This ensures the flexibility and optimality of choosing one or another DBMS in accordance with the requirements for computer systems.

However, the developed technology requires further automation of the process of measuring attribute quality values, since writing SQL scripts and the convenience of their execution are quite time-consuming and require appropriate professional knowledge and skills. Therefore, the further development of the DBMS performance evaluation technology and the authors' attention in the future will be addressed to the development of a CASE tool to ensure the convenience and efficiency of measurements and quality assessment.

References

1. Saha P., Mittal M., Gupta S., Sharawi M. Big Data Trends and Analytics: A Survey. International Journal of Computer Applications. 180 (8). 2017. P. 9–20. https://doi.org/10.5120/ijca2017915926
2. Rawat R., Yadav R. Big Data: Big Data Analysis, Issues and Challenges and Technologies. 1st International Conference on Computational Research and Data Analytics (ICCRDA 2020) 24th October 2020. P. 1–8.
3. Kovtun B. V., Manych A. M., Romanyuk O. V. Porivnyal′na kharakterystyka relyatsiynykh ta NoSQL baz danykh. Materialy XLIX naukovo-tekhnichnoyi konferentsiyi pidrozdiliv VNTU, Vinnytsya, 27–28 kvitnya 2020 r. URL: https://conferences.vntu.edu.ua/index.php/all-fitki/all-fitki-2020/paper/view/9907 (data zvernennya: 27.01.2023 r.)
4. Yatsyshyn V. V. Tekhnolohiya otsinyuvannya yakosti WEB-zastosuvan′. Visnyk Ternopil′s′koho derzhavnoho tekhnichnoho universytetu. 2009. Tom 14. P. 132–140.
5. Sommerville I. Engineering software products. Pearson, 2020. 352 p.
6. Sommerville I., Lock R., Storer T., Dobson J. Deriving Information Requirements from Responsibility Models. Proc. CAiSE 2009. 21st International Conference on Advanced Information Systems Engineering, Amsterdam, June 2009. P. 515–529. https://doi.org/10.1007/978-3-642-02144-2_40
7. Chang E., Dillon T., Sommerville I., Wongthongtham P. Development of a Software Engineering Ontology for Multi-site Software Development. IEEE Transactions on Knowledge and Data Engineering, 2009. P. 1205–1207. https://doi.org/10.1109/TKDE.2008.209
8. Rubey R., Hartwick R. Quantitive measurement of program quality. Proceedings, ACM, International conference. 1968. P. 671–677. https://doi.org/10.1145/800186.810631
9. Hrytsyuk YU. I. Systema kompleksnoho otsinyuvannya yakosti prohramnoho zabezpechennya. Naukovyy visnyk NLTU Ukrayiny. 2022. T. 32. No. 2. P. 81–95.
10. Koval′ H. Pidkhid do keruvannya nadiynistyu ta yakistyu prohramnykh system. Problemy prohramuvannya. 2007. No. 2. P. 56–68.
11. Koval′ H. Pidkhid do modelyuvannya yakosti simeystv prohramnykh system. Problemy prohramuvannya. No. 4. 2009. P. 49–58.
12. ISO/IEC (2011). ISO/IEC 25010 – “Systems and Software Engineering – Systems and Software Quality Requirements and Evaluation (SQuaRE)” – System and Software Quality Models. Technical report. 2011.
13. Kharchenko A., Galay I., Yatcyshyn V. The method of quality management software. 2011 Proceedings of 7th International Conference on Perspective Technologies and Methods in MEMS Design, MEMSTECH 2011. Polyana, 2011. P. 82–84

14. Yatsyshyn V., Pastukh O., Lutskiv A., Tsymbalistyy V., Martsenko N. A Risks management method based on the quality requirements communication method in agile approaches. Information technologies: theoretical and applied problems, 2022. P. 1–10.
15. Harchenko A., Bodnarchuk I., Yatcyshyn V. The modeling and optimization of software engineering processes. Modern Problems of Radio Engineering, Telecommunications and Computer Science – Proceedings of the 11th International Conference, TCSET'2012. Lviv: Slavske, 2012. p. 326.

Список використаних джерел

1. Saha P., Mittal M., Gupta S., Sharawi M. Big Data Trends and Analytics: A Survey. International Journal of Computer Applications. 180 (8). 2017. P. 9–20. https://doi.org/10.5120/ijca2017915926
2. Rawat R., Yadav R. Big Data: Big Data Analysis, Issues and Challenges and Technologies. 1st International Conference on Computational Research and Data Analytics (ICCRDA 2020) 24th October 2020. P. 1–8.
3. Ковтун Б. В., Манич А. М., Романюк О. В. Порівняльна характеристика реляційних та NoSQL баз даних: матеріали XLIX наук.-техніч. конф. підрозділів ВНТУ, м. Вінниця, 27–28 квітня 2020 р. URL: https: //conferences.vntu.edu.ua/index.php/all-fitki/all-fitki-2020/paper/view/9907 (дата звернення: 27.01.2023 р.)
4. Яцишин В. В. Технологія оцінювання якості WEB-застосувань. Вісник Тернопільського державного технічного університету. 2009. Том 14. С. 132–140.
5. Sommerville I. Engineering software products. Pearson, 2020. 352 p.
6. Sommerville I., Lock R., Storer T., Dobson J. Deriving Information Requirements from Responsibility Models. Proc. CAiSE 2009. 21st International Conference on Advanced Information Systems Engineering, Amsterdam, June 2009. P. 515–529. https://doi.org/10.1007/978-3-642-02144-2_40
7. Chang E., Dillon T., Sommerville I., Wongthongtham P. Development of a Software Engineering Ontology for Multi-site Software Development. IEEE Transactions on Knowledge and Data Engineering, 2009. P. 1205–1207. https://doi.org/10.1109/TKDE.2008.209
8. Rubey R., Hartwick R. Quantitive measurement of program quality. Proceedings, ACM, International conference. 1968. P. 671–677. https://doi.org/10.1145/800186.810631
9. Грицюк Ю. І. Система комплексного оцінювання якості програмного забезпечення. Науковий вісник НЛТУ України. 2022. Т. 32. № 2. С. 81–95.
10. Коваль Г. Підхід до керування надійністю та якістю програмних систем. Проблеми програмування. 2007. № 2. С. 56–68.
11. Коваль Г. Підхід до моделювання якості сімейств програмних систем. Проблеми програмування. № 4. 2009. С. 49–58.
12. ISO/IEC (2011). ISO/IEC 25010 – «Systems and Software Engineering – Systems and Software Quality Requirements and Evaluation (SQuaRE)» – System and Software Quality Models. Technical report. 2011.
13. Kharchenko A., Galay I., Yatcyshyn V. The method of quality management software. 2011 Proceedings of 7th International Conference on Perspective Technologies and Methods in MEMS Design, MEMSTECH 2011. Polyana, 2011. P. 82–84
14. Yatsyshyn V., Pastukh O., Lutskiv A., Tsymbalistyy V., Martsenko N. A Risks management method based on the quality requirements communication method in agile approaches. Information technologies: theoretical and applied problems, 2022. P. 1–10.
15. Harchenko A., Bodnarchuk I., Yatcyshyn V. The modeling and optimization of software engineering processes. Modern Problems of Radio Engineering, Telecommunications and Computer Science – Proceedings of the 11th International Conference, TCSET'2012. Lviv: Slavske, 2012. p. 326.

УДК 004.4

ТЕХНОЛОГІЯ ОЦІНЮВАННЯ ПРОДУКТИВНОСТІ РЕЛЯЦІЙНИХ СИСТЕМ КЕРУВАННЯ БАЗАМИ ДАНИХ У ПРОЦЕСІ ПРОЕКТУВАННЯ КОМП'ЮТЕРНИХ СИСТЕМ

Василь Яцишин; Олег Пастух; Андрій Паламар; Руслан Жаровський

Тернопільський національний технічний університет імені Івана Пулюя, Тернопіль, Україна

Резюме. *На основі рекомендацій міжнародного стандарту ISO 25010 розроблено формалізовану технологію оцінювання продуктивності реляційних систем керування базами даних при проектуванні комп'ютерних систем та з урахуванням особливостей класу програмного* *забезпечення, до якого відносяться такі програми. При проведенні дослідження встановлено, що представлення якості СКБД найдоцільніше виражати у термінах моделі зовнішньої якості. Це зумовлено особливостями доступу до програмного коду програмного забезпечення та повнотою характеристик якості. Для кількісного вираження атрибутів за характеристикою «Продуктивність» необхідно обґрунтувати метрики для вимірювання атрибутів, отримати вхідні дані для оцінювання та розробити елементарні функції для оцінювання атрибутів. Для проведення оцінювання атрибутів підхарактеристики «Часова ефективність» у роботі запропоновано відповідні метрики оцінювання та елементарні функції. Побудована технологія оцінювання продуктивності СКБД, як компоненти комплексної характеристики якості, базується на визначених та запропонованих атрибутах і метриках з урахуванням класу програмного забезпечення. Завдяки розробленим функціям оцінювання якості атрибутів, забезпечено науково-обґрунтований та практично-орієнтований підхід щодо формування множини кількісно виражених значень якості атрибутів конкретних СКБД. Це дає змогу підвищити ефективність прийняття рішень при виборі кращих альтернатив для зберігання та управління даними в процесі проектування комп'ютерних систем. Розроблений метод оцінювання продуктивності реляційних СКБД передбачає виконання процедур локального, частинного та інтегрального оцінювання якості, що дозволяє визначати пріоритети атрибутів на різних рівнях. Це забезпечує гнучкість та оптимальність вибору тієї чи іншої СКБД відповідно до вимог, які висуваються до комп'ютерних систем.*

Ключові слова: *технологія, оцінювання, продуктивність, система керування базами даних, комп'ютерна система.*

https://doi.org/10.33108/visnyk_tntu2023.01.054 *Отримано 18.01.2023*