



## LOGIC-STATISTICAL INFORMATION MODELS IN CONTROL FUNCTION OF ACCOUNTING

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### **ABSTRACT**

The article deals with theoretical substantiation and development of an approach to the control function implementation on the basis of automation control application process and the use of logicstatistical information models (LSİM). The basis for development of the approach to the improvement of monitoring over the accounting objects is LSİM which allows automatically identify deviations from the established norms. In contrast to the existing approaches the proposed here development provides instant formation of signal (signal document) about the critical state of an object. The use of LSİM in the process of automation control allows quickly correct the imbalances in the state of objects and lead them in compliance with the accepted norms through appropriate management decisions. The result of this application development is holding objects within optimal limits. This will promote the rational use. Originality of the proposed approach lies in the fact that detailed analysis of the accounting object is conducted not for all factors, but only for those that go beyond the optimal zone. This greatly reduces the amount of information and data to be analyzed.



In addition, the use of LSİM allows controlling the volume (size) of the accounting object or each period of time, keeping them in a certain framework and providing the most optimal ratio by making appropriate management decisions. The use of the recommended here approach allows controlling the facility and gaps through the administrative impact on its status.

**Keywords:** The object of accounting, controlling, critical limits, logic-statistical information models (LSİM)

## 1. INTRODUCTION

The study of available foreign scientific literature on the application areas of logical-statistical information models suggests that basically such a direction is actively studied mainly in technical sciences and statistics. In particular, research concerns logical statistical models (LIS) (SINGH, et al., 2008; KAMEYA; UEDA; SATO, 1999; BONNET; GEHRKE; SESHADRI, 2001) and general statistical information model (GSIM) (GENERIC STATISTICAL INFORMATION MODEL (GSIM): STATISTICAL CLASSIFICATIONS MODEL REPRINT OF UNECE DOCUMENT, 2015).

The first has a number of practical applications, the most famous of which are touch devices and sensors. In this context, attention should be paid to the scientific studies of Methodology for In-Network Evaluation of Integrated Logical-Statistical Models by such authors as Anu Singh, C. R. Ramakrishnan, I. V. Ramakrishnan, David S. Warren and Jennifer L. Wong (S SINGH, et al., 2008).

The general statistical information model is the result of scientific research of 19 members from 13 different national and international organizations dedicated to issues of harmonization of statistical information representation through identical classification approaches. This conceptual model defines the basic concepts related to the structuring of statistical metadata, and the developed classification provides the basis for the formation of a statistical indicators system. The model is structured in two levels. The first consists of positioning the types of objects (for example, statistical classification, and product classification). The second one - characterizes the attributes that are associated with these objects (GENERIC STATISTICAL INFORMATION MODEL (GSIM): STATISTICAL CLASSIFICATIONS MODEL REPRINT OF UNECE DOCUMENT, 2015).

In Ukraine, the problem of logical-statistical information models (LSIM) application is represented by many publications of such authors as Shurmovs'ka and Nykolajchuk (2011) and other specialists in the technical sciences field.

Thus, logical-statistical information models in the modern world are widely used in the field of technical and other sciences. Their characteristics allow solving important issues related to the control of various parameters in the operation of industrial and domestic appliances and equipment, and the like. In our opinion, such models can be adapted for various objects that require monitoring and evaluation.

Since the task of accounting is to control the state and movement of objects of accounting, for this area of human activity logical-statistical formation models are also suitable. According to the sources that were available, we could not make sure that they are used by the accounting systems of Ukrainian enterprises. Accordingly, their adaptation description for accounting purposes was not found. Following the scientific ethics, we do not believe that such studies are absent in general, but they are not represented in the Ukrainian scientific literature.

Due to the difficulties of understanding and perception of our proposals, related to the fact that such a scientific search is at the junction of two technical and accounting sciences, we present in this article the results of the first part of our research, which was published in Ukrainian. Unfortunately, at the moment these are only theoretical substantiations that are not embodied in the practice of accounting. However, we hope that their research and emphasis on relevance contribute to solving this problem.

## **2. RESEARCH REVIEW**

The formation of an effective signaling system integrated with an accounting system of budget institutions to provide prompt management of accounting objects belongs to innovative areas of its improvement. Purely from a technical position, this approach can be positioned as a diagnosis of accounting object's condition in the context of its accounting display. Parameters of such diagnosis would have to be expressed by some quantitative indicators.

The simplest example of such diagnosis is a detection of emergency and pre-emergency states of complex industrial facilities. Basically, the problems of diagnosis of the condition of objects management are systematically examined by scientists of

technical sciences for the creation or an improvement of information systems of management by complex objects.

In particular, such scholars as Andrushko (2008), Guchii (2013), Zinchenko (2014), Nykolaichuk (2006), Pitukh (2006), Fraier, (2008), Shyrmovska (2010, 2011, 2013), Velychko (2017) and Shevchuk (2008), carried out their investigation in this area as the relevance of conducting such research is dictated by the need to prevent emergency situations and control over the technological processes to keep them in the required conditions (modes) because at least quantity and quality of manufacturing products depends on this, and more globally – public security. The use of a similar practice with accounting objects also seems to be appropriate because it will facilitate an efficient provision of financial and material support and the rational organization of process of providing services in general. In addition, the development of such a trend in modern conditions is especially relevant due to the existence of problem to provide an optimization of resource potential of business entities.

One of the most effective and high-speed systems capable of providing impartial and prompt information for management needs is a computer form of accounting. However, despite its undoubted advanced nature and numerous advantages in domestic practice, they are also insufficiently analytical and they lack a control ability. Accordingly, an objective which needs to be solved is an assessment of the problems and causes that hinder an implementation of increased use of computer technology to perform analytical and control procedures with accounting data and generalization of principles of accounting modernization and their impact on description models and types of sources of accounting information.

The following thesis enhances the need for this approach. It is believed that in recent years (SINCE, 2011) technologies of business analysts have been significantly widespread; they are aimed at accelerating administrative decision making that they can provide the best option of an activity implementation and the use of resource potential. The possibilities for an application of these approaches depend on the professional skills of employees and their effectiveness.

Accounting system in this context should meet the following criteria, and therefore the formation of recommendations for methodological support for achieving no subsequent data processing and output of results when it is impossible to apply managerial influence on them (as it is inherent in accounting of budget institutions),

but in the process of critical states is more relevant. It is fair to mention, for example, that the electronic systems of payments, which are used in banking, contain some elements that fit the accounting system's parameters, which should be developed in budget institutions and, hopefully, which we will justify.

Generally, we talk about the fact that at the end of the transaction day, the system of electronic payment can immediately form the result data. In addition, when there is a task to recalculate the amount of money that does not match a balance on account, the transaction is automatically positioned and shown in real time in a dialogue mode in the form of a corresponding signal. Instead, in budget institutions, in some cases, this fact can be found only after the orders were made for conducting business transaction and appropriate primary documents (e.g. invoices) were issued.

To form a system of accounting that would respond timely to avoiding situations where the amount of values was issued in accordance with the original document but they are not actually in the right amount, i.e. system that can provide some control of critical states of accounting objects, it is necessary to give their definition. As it has already been emphasized, there are currently no studies about the objects of accounting of budget institutions.

Basically, the issues of diagnostics of the state of management objects are systematically examined by technical sciences scientists for the creation or an improvement of information systems of complex management objects. The relevance of such research is dictated by the need to prevent the emergency situations and to control over the technological processes to keep them in the necessary conditions (modes) because at least the quantity and quality of manufacturing products depend on it, and more globally public security does.

Some scientists believe that diagnostics of the management objects states is the task of situational analysis that is the determination of a set of managed regular situations of a complex system and forecasting possible abnormal and critical situations in its functioning (ZGUROVSKYI; PANKRATOVA, 2007; PUSTYLNICK, et al., 2017).

In the final version, such systems must ensure the prevention of failure and the destruction of an object or a release (production) of low-quality product (NYKOLAICHUK; SHYRMOVSKA, 2011). The process of providing services by budget institutions, especially by medical and educational institutions, can be attributed to complex management objects. Accordingly, its consideration from the

accounting point of view as the basis for managing this process should embrace issues aimed at functional improvement of informational accounting data and providing timeliness of their consideration for the smooth implementation.

One of the most effective ways to achieve this task, as it has been proved, is diagnostics of a condition of accounting objects to keep them at an optimum level. From this position, the state of object management can be defined as a state that is identified by accounting system by certain, well-defined mathematically expressed parameters.

The disadvantage of the current system of budget institutions accounting in this respect is insufficient functionality and low information content of data that is caused by the static of measuring parameter values of accounting objects. In most cases the methods of amplitude measurement controlled parameters are not applicable to them even though at a low and short-term deviation from the norm, such as the delay of financial provision, there may be substantial interference in the organization of service.

It is most clearly manifested when due to underfunding budget institution is unable to pay utilities. Having some legislative instruments the provider of these services can apply some to them such as a disconnection of gas supply, electricity and so on. During the winter period, such an action eliminates the possibility of budget institution to provide services.

Providing with the accounting system to prevent such situations, including through timely detection of deviations from the norms of spending values and money will help stabilize activities and achieve the mission of providing quality services and achieving budgetary savings. In this respect, modern scholars and practitioners express the opinion that the in-market conditions issues of data detail are actualized to analyze deviations of actual results from planned (or most optimal) (GOLOV, 2005; PUSHKAR; CHUMACHENKO, 2011).

The objective of this analysis is to prevent failures, unanticipated costs, and to provide activity optimization of budget institutions in general. The conditions of the use of logical and statistical information models (LSIM) (NYKOLAJCHUK, 2010) meet the opportunities for solving this problem; in terms of computerization they can be implemented by means of appropriate software.

Research available to foreign scientific literature regarding the areas of an application of logic-statistical information models allows asserting that basically this

direction actively studied mostly in technical sciences and statistics. Moreover, usually scientific research concerning the logic of statistical models (LIS) (SINGH, et al., 2008; KAMEYA; UEDA; SATO, 1999; BONNET; GEHRKE; SESHADRI, 2001) and general statistical information model (GSIM) (MEETING OF THE EXPERT GROUP ON INTERNATIONAL STATISTICAL CLASSIFICATIONS NEW YORK).

The first has a number of practical applications of the most famous of which is the sensory devices and sensors. In this context, it should pay attention to Research Methodology for InNetwork Evaluation of Integrated Logical-Statistical Models of such authors as Anu Singh, et al. (2008). General statistical information model is a result of scientific researches of 19 members from 13 different national and international organizations devoted to coordination of statistical information through the identical classification approaches.

This conceptual model defines the basic concepts that are related to the structuring of the statistical metadata and that developed the classification provides the basis for the formation of the system of statistical indicators. The models are structured in two levels. The first consists of positioning of the object types (for example, statistical classification, the classification of goods).

The second describes the attributes of those objects related to the Generic Statistical Information Model (GSIM) (Meeting of the Expert Group on International Statistical Classifications New York, 19-22 May 2015.). These models, as well as research of logic-statistical information models can be adapted for different objects that require control and an assessment. Accounting for the needs of the most appropriate, in our view, is a logic-statistical information model.

### **3. DATA AND METHODOLOGY**

The study of the possibilities of using logical statistical information models (LSIM) for accounting purposes is connected with the need for on-line monitoring of the state of accounting objects, on which more than 75 percent of all managers of various levels of management surveyed have focused their attention. For effective management, managers need operational data indicating the critical state of accounting objects, namely, data on their lack or excess. Other information is not relevant for managers, because management decisions will not be made, if the object of accounting is available, which will not fail in the production process or the provision of services.

Logical statistical information models allow to monitor and identify the state of accounting objects which are beyond the norm. Currently such models are not used in Ukrainian accounting. In this case, according to the existing classical descriptions, which can be found in the literature on technical sciences, LSIM are designed to control the deviations of the states of control objects from the norm. Accordingly: LSIM-1 - by amplitude; LSIM-2 - by dynamics; LSIM-3 - by phase; LSIM-4 - by spectrum; LSIM-5 - by global dispersion, etc. (SINGH, et al., 2008; SHYRMOVSKA; NYKOLAJCHUK, 2011).

The article describes modifications of LSIM for accounting purposes. An analogy was used for this, since accounting objects like management objects and an assumption (a hypothesis) was made that the use of LSIM in accounting is possible and necessary to strengthen the control function of the state of accounting objects. To substantiate the advantages of LSIM in accounting, the method of generalization and evaluation was used. The development of a documentary support system for displaying the results of control of accounting objects using LSIM was carried out on the basis of an analogy with standardized accounting forms of documents and the formalization of linguistic, physical and mathematical components of signal control documents.

#### **4. THE INTERVIEW FINDINGS**

##### **4.1. The essence and peculiarities of using LSIM-1 for monitoring deviations of the volume of financial provision in budgetary institutions**

Existing types of LSIM can be adapted for use with accounting purposes, subject to the implementation of appropriate adaptation and the development and formation of formulas (formalization), describing the accounting parameters. The specifics of the object of accounting should be taken into account. It affects the choice of indicators that should be taken into account when developing formulas that will be used to establish the critical limits of the accounting item state.

An example illustrating the approach to the formalization of the lower and upper critical points of the financial support volume for the activities of an institution financed from the budget is presented below.

The essence of the first LSIM consists in revealing (identification) deviations of the volume of financial provision by the amplitude. At the same time setting limits of the permissible norms within which it is advisable to keep the volume of financial

provision for the achievement of normal activity of budgetary institution, should be calculated as follows:

a) lower marginal limit (Fikmin):

$$(Fikmin) = (F1min + F2min + F3min) \times li / 3, \quad (1)$$

where F1min, F2min and F3min – respectively, the minimum monthly volume of financial provision for the previous three years;

li – average level of inflation for the last three years;

b) lower limit value (Fikmax):

$$(Fikmax) = (F1max + F2max + F3max) \times li / 3, \quad (2)$$

where F1max, F2max и F3max – respectively, the maximal monthly volume of financial provision for the previous three years. Immutability of methodology for conducting calculation of the volumes of financial provision serves substantiating the choice of data for previous years and accounting of inflation allows you to bring these figures to the actual value estimates.

Also, other approaches to establishing thresholds can be used, namely, depending on their own set benchmarks and acceptable limits calculated by their own methodology; based on the achieved of minimum and maximum levels of monthly financial provision of similar entity that has better results of activity; by the established standards at the state level.

More expanded research on the use of LSIM to control financial security is presented in article «Logic and statistical informational models and prospects of their use for diagnosing the state of the financing process of budgetary institutions» (KHORUNZHAK, 2013). The formalization of the establishment of boundary critical funding limits is proposed in this paper, an illustration of the possible values of the Boolean variables and the modification of LSIM-1 according to different scenarios is presented, and also a general block diagram of the control of the state of objects of the accounting is constructed. In general, a similar approach to control can be applied to the state of any accounting objects. This requires:

- to substantiate the approach to establishing the critical boundaries of the object of accounting scientifically (for example, stocks, cash at the cash desk, cashless funds on bank accounts, etc.);
- to identify factors that affect the volume of a particular object;

- to develop formulas for the establishment of the upper and lower limits (to formalize the boundaries).

The main problem in this case is that for different subjects of management, the critical boundaries of accounting objects will be different. This is primarily due to the difference in the scope of activity. In addition, the boundaries depend on the object itself. In particular, if you take stock, then the critical limits on them will also depend on the frequency of deliveries (1 time in a quarter, 1 time per month, once every 10 days or daily).

Instead, the types of formation of the values of the vector of any accounting object according to the first LSIM under different scenarios (within the norm, insufficient, excessive, etc.) will be as illustrated in the above article (KHORUNZHAK, 2013) regarding financial ensure.

LSIM can also be used to control other objects of accounting, for example, inventories. In this case, setting the critical limits will require taking into account other parameters, but the further steps of the algorithmization may be the same for all accounting objects.

In particular, the model of each accounting object in terms of the amplitude LSIM (LSIM-1) is described by a vector of Boolean variables:

$$L1 = \{f_1, f_2, K, f_m\}, \quad (3)$$

where  $m$  – is the sample size (can be selected depending on the needs of the monitoring time interval: daily, weekly, monthly, quarterly).

During the selected time interval, a sequence of vectors is formed, characterizing the volume of availability of the accounting object at each discrete point in time. The value of Boolean variables is determined by the following condition:

$$f_{i_k} = \begin{cases} 0, & \text{at } F_{i_k} \in E1_i; \\ 1, & \text{at } F_{i_k} \notin E1_i, \end{cases} \quad (4)$$

where  $F_{i_k}$  is the amplitude value of the object of accounting in the  $i$  time interval (if necessary, the time period can be selected in 1 day, 1 week, 1 month, 1 quarter or 1 year;  $k$  - discrete system time;  $E1_i$  - aperture of the volume tolerances of the accounting object in -  $i$  time moment.

The use of LSIM-1, despite the existing features of accounting objects, may have several modifications. They appear on the charts as going beyond the established limits.

Accounting data characterizing the volumes of controlled accounting objects and the corresponding apertures are described to determine the coordinates of the condition vector:

$$f_i = \begin{cases} 0, & \text{at } M_{F_i} \in E11_i; \\ 1, & \text{at } M_{F_i} \notin E11_i; \end{cases} \quad f_i = \begin{cases} 0, & \text{at } M_{F_i} \in E12_i; \\ 1, & \text{at } M_{F_i} \notin E12_i; \end{cases} \quad f_i = \begin{cases} 0, & \text{at } D_{F_i} \in E13_i; \\ 1, & \text{at } D_{F_i} \notin E13_i, \end{cases} \quad (5)$$

where the first condition implies an estimate of the selective mathematical expectation, the second - an estimate of the moving expectation, the third - an estimate of the variance.

The advantage of the considered LSIM modifications is the insensitivity to individual random deviations of the accounting object volumes, the integral sensitivity of the model and the reduction of data volumes.

Figure 1 shows conditional examples reflecting the principle of the formation of Boolean variables in LSIM-1 and its modifications for assessing the state of accounting objects.

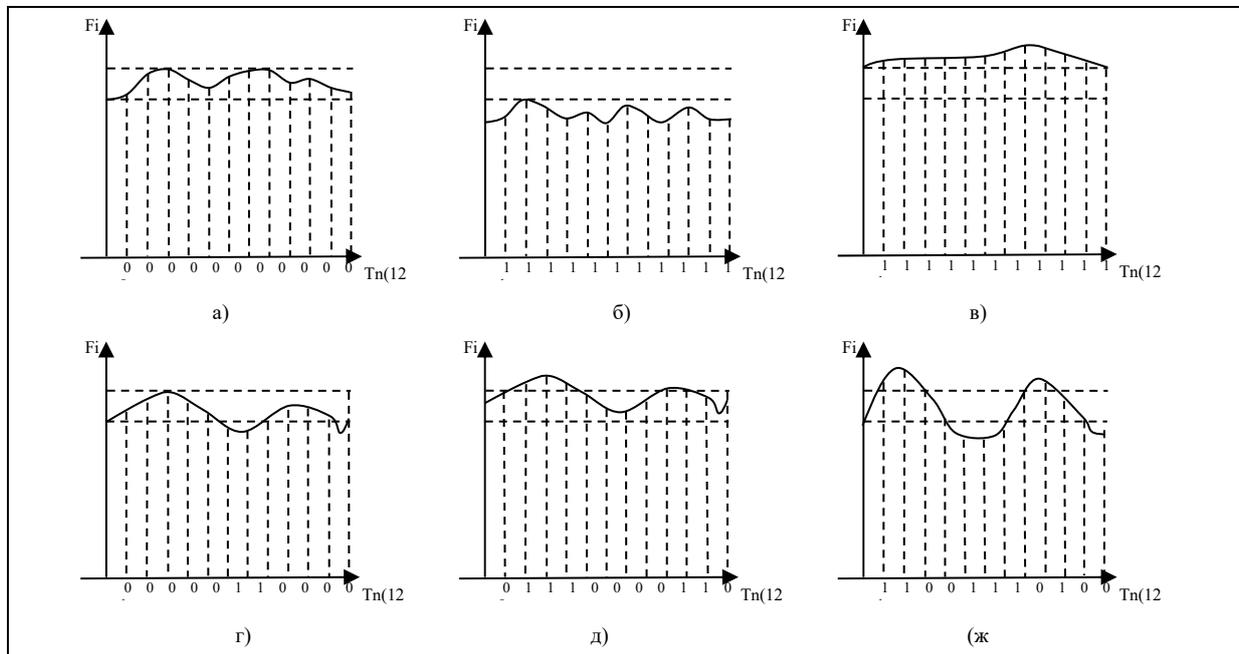


Figure 1: Formation types of the vector values of the accounting object volume due to the LSIM-1 in different scenarios

**Legend:** a) object of accounting within the normal range; b) insufficient volume of the accounting object; c) the excess volume of the object of accounting; d) accounting object of the "norm + insufficiency" type; e) accounting object of the "norm + excess" type; g) accounting object of the "excess + norm + insufficiency" type.

However, the feature of the recommended approach is not so much the control over the observance of the established boundaries of the volume of accounting objects, as building an accounting system capable of maintaining their content at an optimally reasonable level acceptable for carrying out activities in an amount that corresponds to the planned performance of a business entity. That is, the given examples of LSIM-1 modifications are the basis for further substantiation of the signal module formation of the accounting system, which is based on diagnostics of the state of the accounting object (financial support was taken as an example).

At the exit points of the chart beyond the set limits of the accounting object, the function takes the value 1, and being in the zone of optimality is equal to 0. It is advisable to output the deviations detected in this way as a signal register with the "Critical deviations" column, in which the deviation from the norm should be marked with a certain red sign (for example, "Danger"). In the future, when the output of the accounting object by the threshold value, it is necessary to conduct a more detailed data analysis.

The value of the proposed approach is in the fact that detailed analysis is not carried out for all indicators, but only for those that go beyond the optimal zone. This significantly reduces the amount of information data that needs to be analyzed. In addition, the use of LSIM allows to control the accounting objects volume for each period of time, to keep them within certain limits and to enable the most optimal ratios by making appropriate management decisions.

The use of the recommended approach will allow continuous monitoring of the accounting object and interference to be investigated, due to management influences on its state. In the conditions of computerization of the use of such a system does not require significant costs, and in the case of coverage of all accounting objects, will allow to quickly monitor all processes and instantly identify deviations from the established norms.

By itself, the control function of accounting has practical implications, but its significant disadvantage is post fixation. That is, it turns out the fact of the presence of deviations from critical norms after conducting an economic operation. For a modern business and economic environment, this situation does not contribute to the early warning of potential threats. Therefore, further scientific research should focus on the possibilities of using other types of LSIM. This will ensure the systematic and consistent research, including the issue of strengthening the control function of

accounting for such an object of accounting as financial provision of budget institutions.

#### 4.2. Characteristics and examples of formation values of LSIM 1-4 and methods of construction for cluster models and global dispersion for indicators of financial provision

Obtaining information about the dynamics of the accounting objects in time is no less important for management system. Such accounting information is necessary for the assess trends in resource usage, detecting the presence of seasonal prevalence and its impact on the result indicators, ensuring optimization of volume of accounting objects with the activities, etc. The use of the second LSIM will be useful in this context. Formation of coordinates of the logical vector (L2), which can be carried out with use of other autocorrelation assessments:  $K_{xx}(j)$ ,  $C_{xx}(j)$ ,  $G_{xx}(j)$ ,  $F_{xx}(j)$  in a role of functions that characterize the dynamic properties of accounting objects (in this example, indicators of financial provision). Thus, it is necessary to choose appropriate significance  $j_0$  and E2.

The example of the formation of values for the second LSIM of annual indicators of financial provision by changing the dynamics of time was presented in Figure 2.

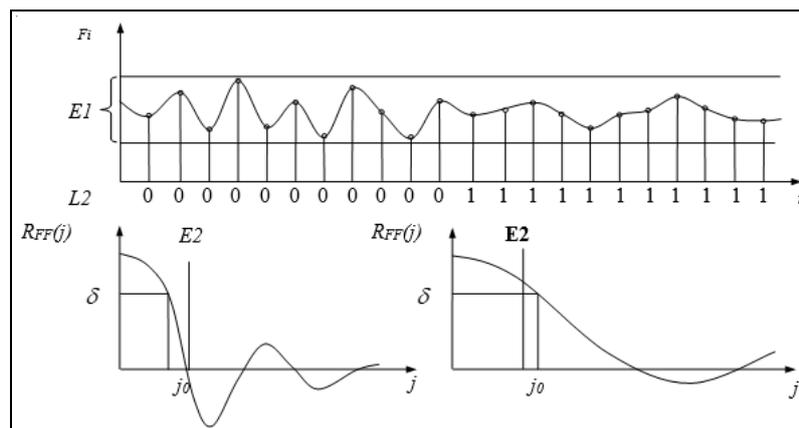


Figure 2: Formation of values for the second LSIM

The second LSIM can be modified, which will allow expanding its functional capabilities for the control of dynamics of financial provision of budgetary institutions. The modification consists in the fact that the analysis of correlation assessments is carried out not at one meaning  $j_0$ , but on some interval  $(j_1, j_2)$  (Figure 3).

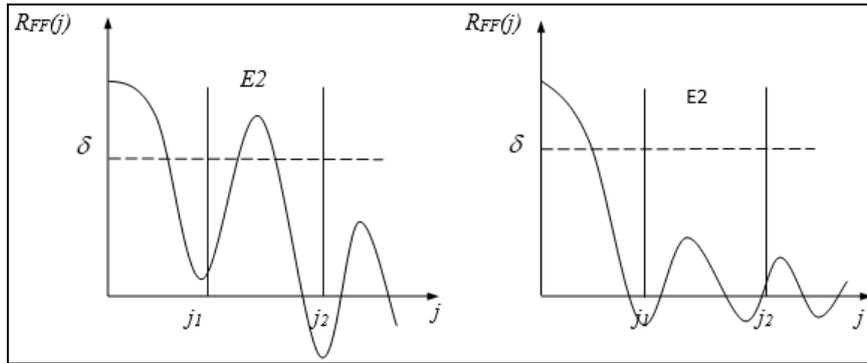


Figure 3: Examples for installation of interval apertures in the second LSIM for indicators of financial provision

The procedure for determining coefficients of cross-correlation between two controlled characteristics of accounting objects (indicators of financial provision) underlying the third LSIM. In other words, the third LSIM responsive to the phase changes of two characteristics of indicators for financial provision. As all previous models, the third LSIM is described by the vector of Boolean variables but

coordinates  $C_i$  are determined by another condition:  $L3 = \{c_1, c_2, \dots, c_m\}$ ,

but the coordinates  $C_i$  are determined by another condition:

$$c_i = \begin{cases} 0, & \text{at } \rho_{F_i, e_i}(j) < E3_i; \\ 1, & \text{at } \rho_{F_i, e_i}(j) \geq E3_i, \end{cases}$$

where  $\rho_{F_i, e_i}(j)$  – normalized coefficient of cross-correlation between  $i$ -indicator of financial provision  $F_i$  and the corresponding benchmark of state  $e_i$ .

The essence of the third LSIM is to identify phase deviations of monitored indicators of financial provision from the norm (Figure 4).

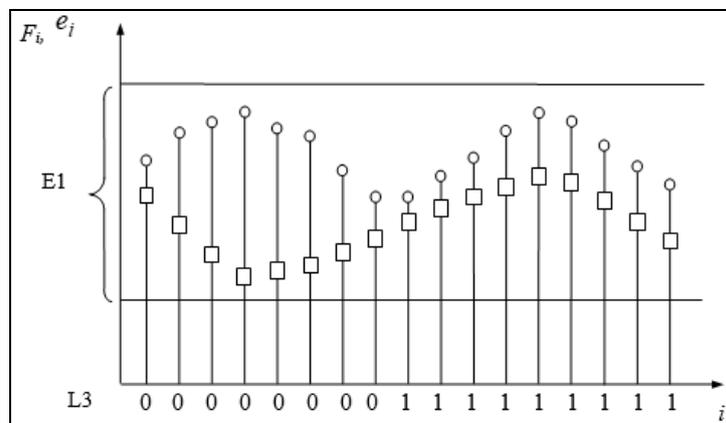


Figure 4: Formation of the Boolean variables in the vector of the third LSIM.

The spectral analysis of indicators of financial provision that describes its states in certain period was the basis of the fourth LSIM. The set of harmonics  $E_4$  with frequencies  $\omega_1, \omega_2, \dots$  that must be present in the indicators of financial provision in the normal state of financing is set or defined. The set of harmonics  $A$  where the studied parameters are decomposed in a given basis is defined by conducting a spectral analysis of controlled parameters (Figure 5).

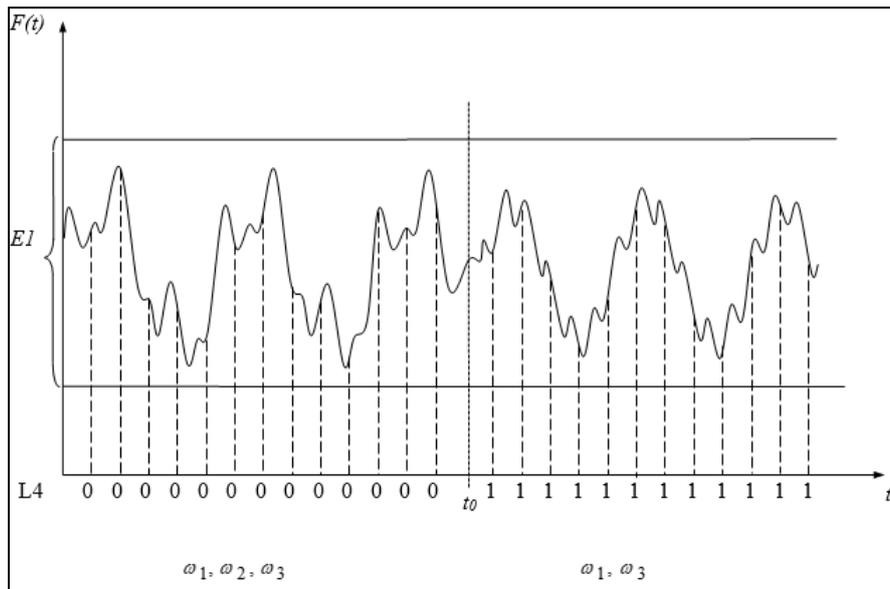


Figure 5: Formation of logical values for the fourth LSIM by changing the spectral composition of indicators of financial provision.

A logical vector of the fourth LSIM of parameters is formed in this result, which coordinates react to changes of the spectral composition of financial provision in the appropriate moment:

$$L4 = \{d_1, d_2, K, d_m\},$$

$$d_i = \begin{cases} 0, & \text{at } S_{(\omega)} \subset A_i, \\ 1, & \text{at } S_{(\omega)} \not\subset A_i. \end{cases}$$

The model of the global dispersion allows carrying out a systematic assessment of indicators of financial provision when analytical correlations between data do not exist or they are difficult and have cumbersome form. The model was built based on the matrix of crosscorrelation coefficients between indicators of financial provision. Correlation matrix for  $m$  - between certain parameters of financial provision  $\|F_{ij}\|$  has dimensions  $m \times m$  and symmetrical regarding the main diagonal because:

$$F_{ij} = \begin{cases} F_{ji}, & \text{at } i \neq j, \\ 1, & \text{at } i = j; \end{cases}$$

where  $i = \overline{1, m}$ ,  $j = \overline{1, m}$ .

Therefore, informative elements are the matrix elements located under / above the main diagonal. If we assign the ordinal numbers for these elements, we

get sampled cross-correlation coefficients with volume  $N = \frac{m}{2} \cdot (m - 1)$  (Figure 6).

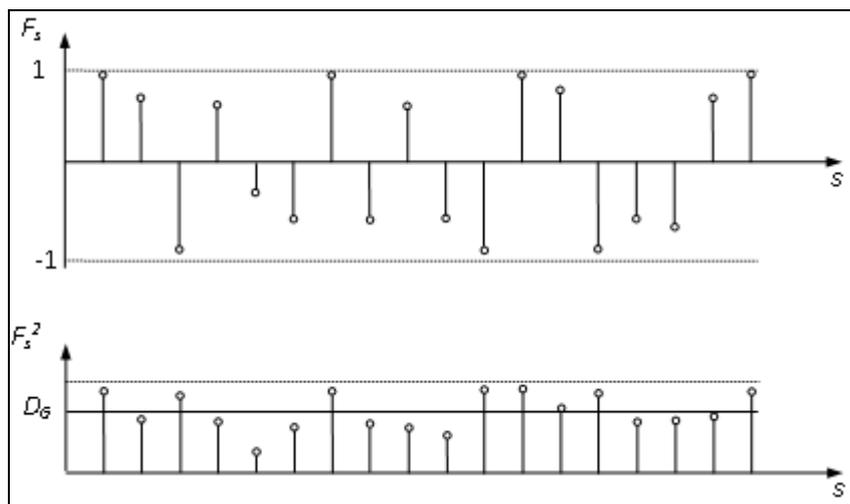


Figure 6: Lattice functions of informative coefficients of cross-correlation and calculated value of global dispersion on their basis

Let's find global dispersion for this sample based on known expression:

$$D_G = \frac{1}{N} \sum_{s=1}^N F_s^2$$

Obtained in this way variance rating is called global (Fig. 5), because it characterizes the overall financial support of budget institutions, considering the statistical relationships between data in different years without analyzing data in certain years. Considering different semantic significance of transitions between states of indicators of financial support when building global variance allows more completely describe its state in budget institutions and the efficiency of global variance increases significantly, especially in enterprises with large difference in significance of transitions. Semantic global dispersion can be described by the following function:

$$D_S = \frac{1}{N} \sum_{s=1}^N \alpha_s \cdot F_s^2$$

where  $0 \leq \alpha_s \leq 1$  – weight function.

An introduction of weight function  $\alpha_s$  leads to increasing information content and dynamic of global dispersion, indicating more sensitivity of the model. Determining the correlation matrix for the account object that is received or used by the multi-channel scheme in discrete moments of time on the interval of observation  $T$ , you can build a lattice function of global dispersion  $D_G$  or  $D_S$  on this interval (Figure 7).

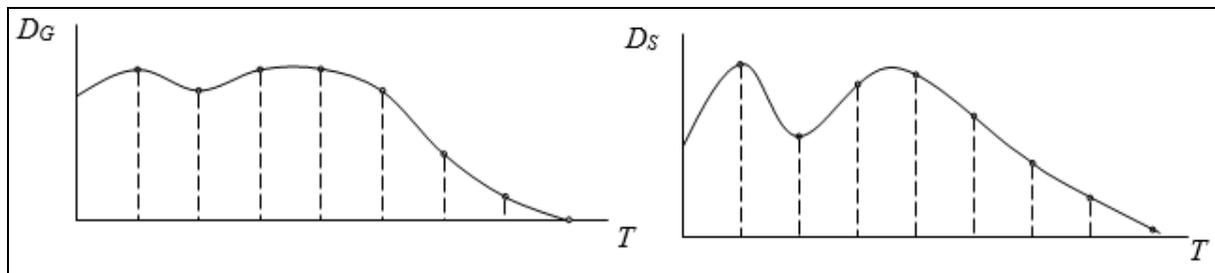


Figure 7: Graph of change in the global dispersion

Value of estimates  $D_G$  and  $D_S$ , as shown in Fig. 6 reflects the average value of correlation connections between indicators of financial provision in the quadratic space. Accordingly, coefficients  $F_{ij}$  are reduced when reducing the statistical dependencies between them. General trend of reduction of coefficients  $F_{ij}$  leads to decreasing  $D_G$  ( $D_S$ ), which indicates the destruction of relationships within the system. In the limiting case, when  $\forall i \neq j r_{ij} = 0$ , to  $D_G = 0$  ( $D_S = 0$ ) and we can conclude about the destruction of all ties, degradation and complete informational breakdown of the system.

The proposed methods of constructing cluster models and global variance for indicators of financial support is an important tool for regular condition control of the accounting object. Similar approaches can be used to other objects (inventory, costs, revenues etc.).

#### **4.3. Tasks that need to be solved for substantiation of the formation of a technical component of the implementation of LSIM in the accounting system**

Using the proposed approaches to improve the quality and efficiency of accounting information for management purposes will increase the expediency and efficiency of spending financial support in the process of carrying out activities of budget service providers. However, the practical implementation of LSIM requires the solution of a number of other no less difficult tasks. They include:

- 1) Development of the system of sources for information (document presentation of results) and tasks for the programming process of their formation. The fulfillment of this task requires taking into account the form of the information on the object of accounting (monetary, monetary and natural) and the format of their presentation (document forms or other), which should be convenient for use by management specialists. It is important to note that modern computer systems are capable for representing digital information in various formats and forms, including in the form of charts, diagrams, scenes, etc. (*technical and economic task*).
- 2) Substantiation of approaches to the formation of accounting documentation (sources of information) by specific hardware. It is necessary to do some stages for its implementation: to evaluate the various types of automatic digital correlators and their structure in order to determine the level of their suitability for implementation of LSIM algorithms; to differentiate the cycles of implementation of the control accounting function with the help of LSIM and to establish the optimal ranges (time intervals) and the limits of accounting indicators; to formalize established ranges and limits (to substantiate the factors and to develop the formulas); to construct algorithms for calculation and implementation of LSIM (*technical + mathematical task + technical and economic*).
- 3) Conducting the analysis of complexity of developed algorithms (in particular, structural, hardware, time and software complexity). We can use already known models of estimation algorithms to do this, or develop more innovative authors with appropriate formalization of their functional. This will make it

possible to choose the most effective from several alternative LSIMs. The choice will be based on the results of the obtained digital indicators of the complexity of the algorithms (*mathematical task*).

- 4) Construction of a block diagram of the process of implementing the control function of accounting on the basis of LSIM corresponding modification. In the above article (KHORUNZHAK, 2013) a general block diagram of the control of the state of objects of accounting on the basis of LSIM is constructed, but it should be subject to refinement and adaptation in accordance with the system characteristics of each of the modifications of LSIM, as well as taking into account the characteristics of each object of accounting. The need for such clarifications can be illustrated by a specific example. If LSIM is used to control cash, then the critical limits are set only in the monetary instrument. With regard to inventory can be set quantitative or quantitative and cost limits (*technical and economic tasks*).

The identification of tasks that need to be solved to ensure the implementation of LSIM in the accounting system is the basis for further scientific research. At the same time, their direction lies in various planes that are systemically interconnected:

- 1) Substantiation of the expediency of using LSIM (through the estimation of complexity of algorithms)
- 2) Choosing a method for diagnosing critical volumes of the object of accounting (by identifying shortcomings of known methods, substantiating ways to eliminate them, and introducing more perfect identifiers of the state of the object of accounting).
- 3) Development of proposals on the technical capabilities of measuring parameters (including sensors, meters, etc.) and the structure of the system as a whole (the composition of the blocks providing input and output information, its encoding, the device for the preparation of records (information), from connecting and transmitting devices, etc.).

A simple analysis of the above tasks and isolated areas of scientific research allows us to confirm that their solution is possible through the use of tools in economic, mathematical and engineering sciences. The process of such study is complicated by the need for an integrated combination of each of the listed

components to solve the problem of implementing the LSIM in the accounting system into a single whole. In fact, in this regard, many good economists' ideas are difficult to implement due to lack of technical knowledge and vice versa. Many successful technical solutions are difficult for perception by economists, and therefore they are not always realized in practical economic activity.

Moreover, the process of strict standardization of accounting and the use of approved unified forms of accounting documentation greatly complicates the introduction of good innovations in this system. An obstacle in this process is also the complex organizational structure of both the actors of the public sector entities (budgetary institutions) and the accounting system in which their subjects operate. By the way, it is necessary to give a clear interpretation of the subjects of accounting in the current normative and legal documents of Ukraine.

This will avoid the problem of duplication of their powers and functions. In addition, the introduction into the activities of public sector entities, in particular budget institutions, subsystem management accounting will solve the problem of non-standard representation of accounting information for management purposes. Examples of the complex functioning of accounting and management accounting in this sector in developed countries indicate the usefulness of this approach.

Investigation of modifications of LSIM in order to establish the possibilities of their use for the purpose of control of objects of accounting allowed simultaneously detecting a number of problem issues and identifying the tasks that need to be solved. These tasks belong to various branches of science (see highlighted in italics), therefore not all can be solved by economists. It is necessary to involve specialists of technical and mathematical sciences practically for the solution of all of them (1-4).

Thus, the proposed theoretical bases for the use of LSIM to increase the efficiency and quality of the control function of accounting predetermine the need for further, no less in-depth research on the directions and tasks that we have outlined.

Due to the volume of such studies, we restrict ourselves to researching the possibility of solving the first part of the problem in this article, namely the development of a system of sources of information.

#### **4.4. Development of information sources: formalization and functional describing components**

First of all, it is necessary to substantiate and formalize their components to solve the task of developing a system of sources of information. These components are traditionally divided into physical, mathematical and virtual in terms of computerized accounting. This approach is quite acceptable for the sources of accounting information. Each component in its composition has certain elements. Moreover, some of them are common (identical) for any systems and some are specific. Instead, the description function of these components will necessarily be different for different systems.

For example, components of information sources for the accounting system in the formalization of their description function must necessarily include: – the established sequence of information formation (input, processing, transmission, approval, storage); – a description of the technical means for realizing the formation of information; – means of managing information arrays; – means of information protection (including software and hardware); – ways of submitting information (format and model), etc. (Fig. 8).

The presented components of the sources of accounting information and the recommended functionalities of their description will become the basis for the following tasks (2-4). In addition, on their basis, it is advisable to develop new forms of documents.

<b>Components of sources of accounting information in a computer accounting system</b>	
Recommended features for description	
Physical:	
PCs (microprocessors, special processors), software and hardware (databases, information read-out and image information), information transfer systems, security	$PK = f_1(P_p, T_{tsh}, R_p, T_d, O_p, P_z, S_{oi}) ; F_1 [ O, \oplus, \otimes, \ominus ] \Rightarrow F_2 [ PAZ = f_2(IK, PK_a, KBD, FK, RS) ; \Rightarrow$ $SPI = f_3(AS, ZS) ;$ $SZI = f_4(PZ, FZ, ZP, OZ)$
Mathematical:	
Algorithms, diagram of data movement, digital processing, system functions, logical and statistical, stochastic, matrix and other	$A_p = f_{n+1}(ZSOO_k, ZSOO_v, A_{zk}, A_k, RO(K \rightarrow P_d \rightarrow Z_d))$ $F_5 [ E_{RD} = f_{n+2}(DM, GM, PTM, STM, TG, SMH, SAO...N)$ $ZO = f_{n+3}(KI, DPI, FPI...IVPI) \Rightarrow$ ... $\Rightarrow F_6[A_k, A_d, A_{iz}, M_{pd}...IVA]$
Virtual:	
Sensors, visual and sound effects, multimedia, Web sites and etc.	$O, \oplus, \otimes, \ominus \rightarrow O, \oplus, \otimes, \ominus$ $F_9 [ \dots, \dots ] \rightarrow V\Theta \Rightarrow F_{10}[TBV, VFKM, VP_2] \Rightarrow$ $O, \oplus, \otimes, \ominus \rightarrow O, \oplus, \otimes, \ominus$

Figure 8: Components of the sources of accounting information and their formalization\*

Source: KHORUNZHAK, N.M. (2013)

**Notes:**  $O, \oplus, \otimes, \ominus$  – respectively: primary source of data – information at the input (contract, primary document); processing of information and its transmission using the appropriate communication channels (including the formulation of accounting postings and documentation: estimates, memorial orders, turnover information, the Journal of the main documentation, balance sheet, reports on the implementation of estimates, etc.); approval of documentation (signatures and other acceptable identification methods); storing information in the database (including for further use for optimization and forecasting purposes);

$PK$  – Personal Computer;  $P_p$  – processor performance;  $T_{tsh}$  – clock frequency;  $R_p$  – bit processor;  $T_d$  – access time;  $O_p$  – memory size (max – the amount of information that can be saved);  $P_z$  – record density (bit /mm);  $S_{oi}$  – rate of information exchange;  $PAZ$  – software and hardware;  $IK$  – intelligent management of data warehousing and their storage;  $PK_a$  – direct management of archival drives involved in the technological processes of accounting, preservation and exploitation of information resources;  $KBD$  – specialized computer database for managing the

index base (encryption of the Chart of accounts, business operations, etc.);  $FK$  – automatic function for converting files of various formats (pdf, txt, gif, doc, rtf) in order to create a universal format that is suitable for viewing and storage, which makes it possible to differentiate the access;  $RS$  – the level of services (providing duplication of data and creating full copies);  $SPI$  – systems for transfer of accounting information;  $AS$ ,  $ZS$  – respectively, analog and digital communication channels;  $SZI$  – information security system;  $PZ$  – software for protection of credentials (information);  $AZ$  – hardware for information security;  $ZP$  – protective transformations of files;  $OZ$  – organizational measures;  $K_e$  – coefficient of efficiency;  $SV$  – cost of the system;  $\sum EF$  – total efficiency of the physical component of the sources of accounting information;  $A_p$  – simple algorithms;  $ZSOO_k, ZSOO_v$  – change of the state of the objects of accounting respectively: in terms of quantity and value;  $A_{sk}, A_k$  – Subconto and Conto analysis respectively (deviations, percentages);  $RO(K \rightarrow P_d \rightarrow Z_d)$  – accounting registers (estimates, consolidated registers (documents));  $E_{RD}$  – diagrams of data movement;  $DM$  – two-dimensional model of the movement of accounting data of budgetary institutions; graph-model (branched tree) of cycles of data traffic movement;  $PTM$  – a parametric time model that covers the description of the accounting system by the relevant conditions;  $STM$  – structural and temporal model of the display of objects with the help of a system of logical equations (for example, accrual of depreciation of fixed assets, calculation indicators to the estimate (is proposed), etc.);  $TG$  – the network schedule for the execution of accounting transactions (including the communication table: source–receiver);  $SMH$  – the system of time constraints (time graph) for performing accounting functions;  $SAO$  – the scheme of algorithm for processing and control of accounting information (graph of connections of accountants, flowcharts of algorithms and programs);  $N$  – other components of the functional;  $ZO$  – digital processing of accounting information;  $KI$  – data encoding;  $DPI$  – discrete submission of information;  $FPI$  – submission of information with the help of functionals (functional presentation of information);  $IVPI$  – other ways of submitting information about objects of accounting (including in the form of video presentations, charts, diagrams, etc.);  $A_k$  – correlation analysis of data;  $A_d$  – dispersion analysis;  $A_{ls}$  – logical and statistical models of analysis;  $M_{pd}$  – matrix data representation;  $IVA$  – other types of accounting data analysis;  $DMMRD$  – two-dimensional matrix model of movement of accounting data;  $TMMRD$  – three-dimensional matrix model of movement of accounting data;  $PMPIRD$  – intermediate models for presentation of information about the movement of accounting data;  $IM$  – simulation models of data movement;  $M_n$  – other models of the movement of credential data;  $\sum EM$  – total efficiency of the mathematical component of the sources of accounting information;  $F_9$  – a functional that provides a visual representation of accounting data (for management and presentations);  $TBV$  – technologies of contactless information interaction;  $VFKM$  – highly developed forms of computer simulation (credentials and models of activity);  $VP_s$  – artificial virtual space (virtual activity models, virtual services);  $GE_{soby}$  (equal to  $\sum EF + \sum EM + \sum EV$ ) – is the global (general) efficiency of the components of the sources of accounting information.

The layout of the recommended form of the report for internal use, called “Operational internal report on diagnostics of the state of the object of accounting” was developed in (KHORUNZHAK N.M., 2013).

The positive side of its use in accounting practice is the possibility of automatically exposing the risk (in the foregoing graph). However, the further

development of this issue requires further substantiation of the approach to risk assessment and its gradation (division). In addition to this report, it is expedient for administrative purposes to formulate on the basis of such additional forms of documents: a report analytical note on the results of monitoring the state of the object of accounting; decision on measures to eliminate the critical state of the object of accounting.

The delineation of these two forms is due to the fact that “Decisions on measures to eliminate the critical state of the object of accounting” may relate to different management units.

Accordingly, it will be recommended to take measures for each of the units that which belong to their competencies. Instead, the “Report Analytical Note on the results of monitoring the state of the object of accounting” may be the only one for everyone.

## **5. CONCLUSION**

Accounting objects, like management objects, require constant monitoring. The hypothesis that LSIM is a promising and modern tool that can be used for accounting purposes and control of its objects is confirmed by assessing the characteristics of various types of LSIM. After appropriate adaptation, LSIM are able to provide the initial information necessary for managing accounting objects.

In our study, such an adaptation was carried out according to the object of accounting as financial support for the activities of a public sector entity (budget organizations).

Our research does not contradict the existing scientific achievements in the application of LSIM to the objects of control. However, such models are common in technical devices. In the field of accounting, in particular in Ukraine, from known sources and practices, we did not find information on the use of LSIM. Therefore, we can assume that they are not used in this area.

On the basis of theoretical and empirical methods (formalization, generalization, analogy, induction, modeling), we determined the possibility of using LSIM for accounting purposes and made their adaptation description. It is obvious; accounting is a system of solid, continuous, documented reflection of economic phenomena and processes. In this case, the result of applying LSIM in this system should be the formation of a specific form of the document. We have proposed the

components of such a document and their formalization. The practical application of the obtained research results requires further developments aimed at preparing programming tasks, building flowcharts of LSIM application algorithms for controlling various accounting objects.

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