Parametric Monitoring of Computing Processes in Information and Computing Systems

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Abstract

In recent years, methods based on modeling have been widely used, as well as experimental methods based on measurements of the parameters of real-time ICS systems on solvable problems. A feature of most known approaches and methods of analyzing the CP is the formal consideration of certain processes and events occurring in the system and characterizing it at various stages of functioning at a logical level. Usually in this case, assumptions of various kinds are accepted, which are caused not by the logic of the ICS, but by the specific nature of the applied mathematical apparatus. Obviously, a different approach is required, which is devoid of this shortcoming. Such an approach can be, for example, operational analysis of computer performance. The method of operational analysis is mainly based on the use of ICS models with queues and requires from an analyst the knowledge of the principles of ICS functioning at a logical level. It is allowing to evaluate the integral performance of the system, which is dependent on a large number of parameters and approximately calculated from the results of measurements without the use of ICS means. Based on the results of approximate calculations, the values of the basic indicators of the ICS are determined and then decisions are taken on the organization of the CP. The peculiarity of this approach (i.e. engineering approach) is to consider from the engineer's point of view the structure of the ICS, the processes and events occurring in it, when it is required to decompose the system; to highlight in its complex structure the backbones and directions for which the IS is distributed; to identify the sets of IS's and parameters that characterize these streams; to establish relationships between threads and their parameters; to develop requirements for the measurement of these parameters; to conduct (by means of measurements) the collection and analysis of statistical data of IS.

Keywords: computing process, analysis of parameters, estimation of parameters, information computing systems.

1 Introduction

The effectiveness of the application of information-computing systems (ICS) in specific conditions depends on the organization of the computing process (CP). With optimal VP organization in regards of some criterion the performance of the ICS - and, consequently, the efficiency - can be increased. Obviously, this explains the heightened interest in the organization of the CP, requiring the conduct of ICS studies operating in a particular mode (single-program, multiprogram with fixed or variable number of tasks, time-sharing and real time).

2 Problem formulation

There are a large number of approaches and methods for analyzing the organization of the CP, which is based on the measurement, modeling and analytical study of the values of certain indicators characterizing the work of the ICS. In recent years, methods based on modeling have been widely used, as well as experimental methods based on measurements of the parameters of real-time ICS systems on solvable problems [1-3].

A feature of most known approaches and methods of analyzing the CP is the formal consideration of certain processes and events occurring in the system and characterizing it at various stages of functioning at a logical level, i.e. from the point of view of an analyst or a system programmer, when individual structural links and the distribution of information streams (IS) between the hardware components of the ICS are not taken into account. Usually in this case, assumptions of various kinds are accepted, which are caused not by the logic of the ICS, but by the specific nature of the applied mathematical apparatus. For example, by using methods based on the use of queuing networks as ICS models (queue system models), certain assumptions are made regarding the distribution of the streams entering the system of tasks and the duration of their servicing (decision time), which is caused by the requirement of analytical solvability of the model. In other words, the requirement of analytical solvability of the model imposes a number of additional restrictions [1], which is one of the reasons restraining the use of ICS models with queues.

Another reason for the limited use of these models is that the formal consideration of the CP often leads to undesirable practical consequences - for example, the adoption of incorrect decisions about changing the individual parameters of the CP based on the results of modeling, which made an unrealistic assumption about the distributions of streams entering the system of tasks and the time of their solution. Obviously, a different approach is required, which is devoid of this shortcoming. Such an approach can be, for example, operational analysis of computer performance [3]. The assumptions of this approach are directly related to the logic of the computer, and its conclusions are based on calculations of their performance through the values of operational variables (parameters) measured on a finite time interval, which is allowing to establish simple relationships between parameters and indicators of computer operation. The method of operational analysis is mainly based on the use of ICS models with queues and requires from an analyst the knowledge of the principles of ICS functioning at a logical level. It is allowing to evaluate the integral performance of the system, which is dependent on a large number of parameters and approximately calculated from the results of measurements without the use of ICS means. Based on the results of approximate calculations, the values of the basic indicators of the ICS are determined and then decisions are taken on the organization of the CP [1,3].

In a number of cases, when analyzing CP and studying the properties of ICS for specific applications, researchers and developers of universal and specialized ICS are interested in the differential IS system, which allows to assess the distribution of processes among individual structural components of ICS and, based on this, to make a decision either to improve the organization of the CP or to modernize technical resources. To obtain the differential statistics of IS, it is possible to apply an approach based on modeling and measuring the parameters of ICS information streams at the level of their hardware components (HC), i.e. at the physical level. The peculiarity of this approach (i.e. engineering approach) is to consider from the engineer's point of view the structure of the ICS, the processes and events occurring in it, when it is required to decompose the system; to highlight in its complex structure the backbones and directions for which the IS is distributed; to identify the sets of IS's and parameters that characterize these streams; to establish relationships between threads and their parameters; to develop requirements for the measurement of these parameters; to conduct (by means of measurements) the collection and analysis of statistical data of IS. Based on the results of this analysis, an assessment is made of the distribution of IS among the HC of the system, which allows to identify "bottlenecks" in the organization of the CP or in the ICS structure and outline ways of eliminating them.

3 Solutions

Consider the structure of the generalized information stream (GIS), which conditionally includes all information streams in the modern ICS. By GIS we mean the set of Φ, which are the time-varying sequences of address codes $A(r)$, instructions $K(r)$, microinstructions $M(r)$, data $D(r)$, conditions $C(r)$, control information $V(r)$, interrupt requests $P(r)$, transmitted from sources h to consumers offline formation over the backbones $M_y(y = \overline{1,Y})$. The symbol r is used to distinguish elements of a certain sequence of codes (for example, for $r = Y_{ij}$, the symbol $A(Y_{ij})$ denotes the address of the device Y_{ij}); $r \in R$, where $R = \{r\}$ is the set of values. Suppose that if a sequence of codes contains elements of the same type, then the symbol r is omitted. It is obvious that the code sequences $\Phi^{A(r)}, \Phi^{K(r)}, \Phi^{M(r)}, \Phi^{D(r)}, \Phi^{C(r)}, \Phi^{U(r)}, \Phi^{P(r)}$ are homogeneous information streams and components of the generalized information stream Φ:

$$\Phi = \left\{\Phi^{A(r)}, \Phi^{K(r)}, \Phi^{M(r)}, \Phi^{D(r)}, \Phi^{C(r)}, \Phi^{U(r)}, \Phi^{P(r)}\right\}; \quad (1)$$

$$\Phi = \bigcup_{x \in X} \Phi^{x(r)}; \quad (2)$$

Where x is the symbol used to distinguish the components of the stream $\Phi^{D(r)}$; $X = \{A, K, M, D, C, U, P\}$ is the set of values from A to P. Expression (1) and (2) characterize the structure of the stream Φ, showing its heterogeneity due to the presence of various types of components $\Phi^{x(r)}$.

Any information stream in the ICS can be characterized by the information capacity N, the information transfer speed V, the intensity λ, (the number of determined receipts per unit time), the probability $\Theta(n)$ of the arrival of certain sequences (or probability distribution functions Θ of two random sequences), the time τ between the arrival of consecutive codes (information units) and the time interval T sec of their arrival at certain nodes of the system, the priority π of the selection of sequences for processing, the reliability of transmission ε and magnitude information loss ξ.

Denote by z the value of the parameter $\Phi; z \in Z$, where $Z = \{N, V, \lambda, \Theta(n), \tau, T, n, \varepsilon, \xi\}$ is the set of values from N to ξ. The homogeneous stream $\Phi^{x(r)}$ will be characterized by the parameters $z^{x(r)}; z^{x(r)} \in Z^{x(r)}$; where $Z^{x(r)} = \{N^{x(r)}, V^{x(r)}, \lambda^{x(r)}, \Theta^{x(r)}(n), \tau^{x(r)}, T^{x(r)}, n^{x(r)}, \varepsilon^{x(r)}, \xi^{x(r)}\}$ is the set of values of the parameter $z^{x(r)}$. Since the set Z_Φ of parameters of the generalized information stream Φ includes subsets $Z^{x(r)}$ of parameters of homogeneous information streams $\Phi^{x(r)}$, then for Z_Φ next expression is viable:

$$Z_\Phi = \bigcup_{x \in X} Z^{x(r)}; \tag{3}$$

for the subset $Z^{x(r)}$ viable expression is:

$$Z^{x(r)} = \{z^{x(r)}\}_{z \in Z, x \in X}. \tag{4}$$

Expressions (3) and (4) respectively set the sets of parameters of the generalized Φ and homogeneous $\Phi^{x(r)}$ information streams and reflect their quantitative-qualitative characteristics. In general, for Φ, expressions (2) and (3) can be regarded respectively as its structural and parametric models. Expression (4) is a parametric model of a homogeneous stream $\Phi^{x(r)}$.

Represent the set Z_Φ of parameters of the stream Φ in the form of a matrix:

$$W_{z^{x(r)}} = \begin{bmatrix} N^{A(r)} & V^{A(r)} & \lambda^{A(r)} & \Theta^{A(r)} & \tau^{A(r)} & T^{A(r)} & \pi^{A(r)} & \varepsilon^{A(r)} & \xi^{A(r)} \\ N^{K(r)} & V^{K(r)} & \lambda^{K(r)} & \Theta^{K(r)} & \tau^{K(r)} & T^{K(r)} & \pi^{K(r)} & \varepsilon^{K(r)} & \xi^{K(r)} \\ N^{M(r)} & V^{M(r)} & \lambda^{M(r)} & \Theta^{M(r)} & \tau^{M(r)} & T^{M(r)} & \pi^{M(r)} & \varepsilon^{M(r)} & \xi^{M(r)} \\ N^{D(r)} & V^{D(r)} & \lambda^{D(r)} & \Theta^{D(r)} & \tau^{D(r)} & T^{D(r)} & \pi^{D(r)} & \varepsilon^{D(r)} & \xi^{D(r)} \\ N^{C(r)} & V^{C(r)} & \lambda^{C(r)} & \Theta^{C(r)} & \tau^{C(r)} & T^{C(r)} & \pi^{C(r)} & \varepsilon^{C(r)} & \xi^{C(r)} \\ N^{U(r)} & V^{U(r)} & \lambda^{U(r)} & \Theta^{U(r)} & \tau^{U(r)} & T^{U(r)} & \pi^{U(r)} & \varepsilon^{U(r)} & \xi^{U(r)} \\ N^{P(r)} & V^{P(r)} & \lambda^{P(r)} & \Theta^{P(r)} & \tau^{P(r)} & T^{P(r)} & \pi^{P(r)} & \varepsilon^{P(r)} & \xi^{P(r)} \end{bmatrix}.$$

The rows of the matrix are subsets $Z^{x(r)}$ of parameters characterizing the corresponding streams $\Phi^{x(r)}$, and the columns are homogeneous subsets of parameters characterizing the stream Φ. The elements $z^{x(r)}$ of the matrix $M_{r^{x(r)}}$ are parameters of the stream Φ. The elements pertaining to the row are different types of parameters of the homogeneous stream, and the elements related to the column are the same type parameters of heterogeneous streams. The fixation of the matrix $W_{z^{x(r)}}$ (or its elements)for a given time interval or when performing a certain work on the TDF allows to obtain the necessary data that can be used for statistical analysis of the operation of various HC systems. That includes channels and input-output devices, i.e. to analyze the work of the ICS and organize a CP on it.

The structures considered and the set of parameters of the GIF contain a set of elements by means of which any IS taking place in the ICS can be assigned or presented, i.e. the structural components $\Theta^{x(r)}$ of the stream Θ can be included into the structure of a specific stream $\Theta_{h,l}$ in a certain backbone M_y, and from the set Z_Φ of the parameters of the GIF it is possible to select any subset $Z^{x(r)}$ of parameters characterizing the corresponding backbone information stream $\Phi_{h,l}$. Thus, the expressions (1), (4) and the matrix $W_{z^{x(r)}}$ contain all the necessary components by means of which it is possible to formally describe any IS in the ICS.

Let's consider some dependencies between the indicated parameters of the IS. First of all, note that the information capacity $\mathrm{N}^{x(r)}$ of the stream $\Phi_{h,l}^{x(r)}$ should be understood as the number of transmitted information codes $x(r)$ from the source h to the consumer l defined by the expression

$$\mathrm{N}^{x(r)} = \mathrm{V}^{x(r)}\mathrm{T}^{x(r)}. \tag{5}$$

Usually, in the process of the ICS functioning, the transfer $\Phi_{h,l}^{x(r)}$ between its HC is not carrying out continuously, but at arbitrary time intervals $t_e^{x(r)}\ (e = \overline{1,E})$::

$$\mathrm{T}^{x(r)} = \sum_{e=1}^{E} t_e^{x(r)}, \tag{6}$$

Where E is the number of time intervals; $t_e^{x(r)}$ is the time difference between the end $t_{ek}^{x(r)}$ and the beginning $t_{e\text{н}}^{x(r)}$) of the transfer $x(r)$

$$t_e^{x(r)} = t_{ek}^{x(r)} - t_{e\text{н}}^{x(r)}. \tag{7}$$

Taking into account (6) and (7), expression (5) takes the form

$$\mathrm{N}^{x(r)} = \mathrm{V}^{x(r)} \sum_{e=1}^{E} t_{ek}^{x(r)} - t_{e\text{н}}^{x(r)}. \tag{8}$$

Denote by $n_e^{x(r)}$ the number of transmitted information codes $x(r)$ in the time intervals $t_e^{x(r)}$, then

$$\mathrm{N}^{x(r)} = \sum_{e=1}^{E} n_e^{x(r)}. \tag{9}$$

In the case where the IS is represented as a transmitted blocks of information containing a different number of bytes, the value $\mathrm{N}^{x(r)}$ for the observation period T can be represented as

$$\mathrm{N}^{x(r)}(T) = \sum_{\gamma=1}^{\Gamma} \delta_\gamma^{x(r)}. \tag{10}$$

Where $\delta_\gamma^{x(r)}$ is the number of bytes of information $x(r)$ in the block γ, and Γ is the number of transferred blocks.

The intensity value $\lambda^{x(r)}$ for the stream $\Phi_{h,l}^{x(r)}$ is determined from expression

$$\lambda^{x(r)} = \mathrm{N}^{x(r)}/\mathrm{T}^{x(r)}. \tag{11}$$

Typically, in the process of functioning of multiprogramm ICS's which have a non-stationary and random input stream of tasks, there is a situation when IS is transferred between HC at arbitrary moments of time during the considered period T. In other words, the probability $\Theta^{x(r)}(n)$ that the number n of information codes $x(r)$ comes from the source to the consumer at a given time is equal to the probability of their arrival at any other time. It follows that the probability $\Theta^{x(r)}(n)$ corresponds to a Poisson distribution [5]:

$$\Theta^{x(r)}(n) = \frac{\omega^{-\Omega(n)}\Omega^n(n)}{n!}, \tag{12}$$

where $\Omega(n)$ is the average value of n for a given T.

If it's assumed that the process of transfer of information codes $x(r)$ in streams $\Phi_{h,l}^{x(r)}$, which are distributed between the HC of the considered ICS, is stochastic in nature, then the probability $\Theta(\tau^{x(r)} \le \tau_з)$ of the fact, that the time intervals $\tau^{x(r)}$ between the arrival of these codes will be less than some predetermined number $\tau_з$, corresponds to the exponential distribution for which [4,5] can be described as:

$$\Theta\left(\tau^{x(r)} \le \tau_з\right) = 1 - \omega^{-\tau_з/\Omega(\tau^{x(r)})}, \tag{13}$$

where $\Omega(\tau^{x(r)})$ is the average value of the time $\tau^{x(r)}$.

It is quite possible that for some IS's in a certain ICS there is an equable distribution of the probability of transmission of information codes $x(r)$. Then the value of $\Theta^{x(r)}(n = N)$ will be constant and equal to the probability of transfer of Θ codes $x(r)$at a given moment.

The reliability of the transmission of information codes $x(r)$ in the streams $\Phi_{h,l}^{x(r)}$ is determined from expression

$$\varepsilon^{x(r)} = 1 - \Theta_0^{x(r)}; \quad (14)$$

where $\Theta_0^{x(r)}$ is the probability of an error in the ICS during the transmission of the stream $\Theta_{h,l}^{x(r)}$.

The required level $\varepsilon^{x(r)}$ in the ICS is provided by automatic control and correction of the detected errors during the functioning of the system.

The considered IS parameters and some of the dependencies between them, which are represented by expressions (5)-(14), can be used to calculate the integral and differential performances of individual HC and ICS in general. However, it should be noted that the dependencies between the IS parameters, which are necessary to define certain indicators, are determined in each specific case based on the objectives of the ICS study and the depth of the analysis. The latter also applies to integral and differential indicators, which are introduced if necessary. For example, consider some of these indicators.

For HC, which are simultaneously the source h and the consumer of information streams, an indicator is introduced that characterizes the time $T_s^{\text{зпп}}$ of their occupation by receive-transmit operations equal to the sum of the time spent on transmitting $T_s^{x_h(r)}$ and receiving $T_s^{x_l(r)}$ information codes $x(r)$.

$$T_s^{\text{зпп}} = \sum_{x\in X;r\in R} T_s^{x_h(r)} + T_s^{x_l(r)}, \quad (15)$$

where *s* is the HC index; $s \in S, S = \{s\}$ is the set of indices; $T_s^{x_h(r)}$ and $T_s^{x_l(r)}$ consist of their time intervals $t_\alpha^{x_h(r)} (\alpha = \overline{1,A})$ and $t_\beta^{x_l(r)} (\beta = \overline{1,B})$.

$$T_s^{x_h(r)} = \sum_{\alpha=1}^{A} t_\alpha^{x_h(r)} \quad (16)$$

$$T_s^{x_l(r)} = \sum_{\beta=1}^{B} t_\beta^{x_l(r)} \quad (17)$$

In turn, $t_\alpha^{x_h(r)}$ and $t_\beta^{x_l(r)}$ can be defined as time differences respectively between the ends $t_{\alpha k}^{x_h(r)}$, $t_{\beta k}^{x_l(r)}$ and beginnings $t_{\alpha\text{н}}^{x_h(r)}$, $t_{\beta\text{н}}^{x_l(r)}$ of occupation:

$$t_\alpha^{x_h(r)} = t_{\alpha k}^{x_h(r)} - t_{\alpha\text{н}}^{x_h(r)}; \quad (18)$$

$$t_\beta^{x_l(r)} = t_{\beta k}^{x_l(r)} - t_{\beta\text{н}}^{x_l(r)}. \quad (19)$$

Taking into account (16)-(19), expression (15) can be described as:

$$T_s^{\text{зпп}} = \sum_{x\in X;r\in R} \left[\sum_{\alpha=1}^{A} (t_{\alpha k}^{x_h(r)} - t_{\alpha\text{н}}^{x_h(r)}) + \sum_{\beta=1}^{B} (t_{\beta k}^{x_l(r)} - t_{\beta\text{н}}^{x_l(r)}) \right].$$

To analyze the usage of RAM, I/O devices and buses, usually an index is of interest, which is characterizing the total N_s^{Σ} volume of information codes $x(r)$ transmitted by $N_s^{x_h(r)}(T)$ and received $N_s^{x_l(r)}(T)$ in the time interval T:

$$N_s^{\Sigma}(\text{T}) = \sum_{x\in X;r\in R} \left[N_s^{x_h(r)}(T) + N_s^{x_l(r)}(T) \right]. \quad (20)$$

Taking into account (5), expression (20) is taking form

$$N_s^{\Sigma}(\text{T}) = \sum_{x\in X;r\in R} V_s^{x(r)} (T_s^{x_h(r)} + T_s^{x_l(r)}).$$

When researching the organization of the CP on the existing ICS, as well as in the design of new systems, it is necessary to estimate the utilization coefficient for various types of their HC constituents. Usually, this coefficient is determined [] from the ratio of the equipment load to the maximum load that this equipment can withstand, or from the ratio of the time of equipment occupancy to the total time of its operation. Denote by $\rho_s(T)$ the utilization coefficient of HC, distinguished by the index s, on the interval T. For most HC

$$\rho_s(T) = T_s^{\text{зпп}} / T_s^{\Phi}, \quad (21)$$

where T_s^{Φ} is the total time of HC functioning on the considered interval T, the value of $\rho(T)$ has an upper $sup\rho_s$ and a lower $inf\rho_s$ boundary:

$$inf\rho_s = min\rho_s = 0 \leq \rho_s(T) \leq 1 = sup\rho_s = \max\rho_s.$$

Obviously, in the ideal case, it should be

$$\lim_{T_s^{\text{зпп}} \to T_s^{\Phi}} \rho_s(T) = 1.$$

The integral indicator of the work of HC can be determined with the help of expression (21), and the differential indicators, which may be indicators characterizing the degree of occupancy (usage) of HC by the transfer $\rho_s^{x_h(r)}(T)$ and the reception $\rho_s^{x_l(r)}(T)$ of information codes $x(r)$ on the interval T, are determined from the expressions

$$\rho_s^{x_h(r)}(T) = \frac{T_s^{x_h(r)}}{T_s^{\Phi}};$$

$$\rho_s^{x_l(r)}(T) = \frac{T_s^{x_l(r)}}{T_s^{\Phi}}.$$

To assess the performance of the I/O channels $K_j(j = \overline{1,J})$ performing the functions of the IS distributor in modern ICS and being the central link between different types of external devices (ED), RAM and the central processor, an indicator can be used that reflects their actual capacity $G_{K_j}(T)$ on the interval T:

$$G_{K_j}(T) = N_{K_j(T)}^{\Sigma} / T_{K_j}^{\text{зпп}},$$

Where $N_{K_j(T)}^{\Sigma}$ is the total volume of all information transmitted from K_j and received by it on the interval T; $T_{K_j}^{\text{зпп}}$ of the occupation of K_j by the receive-transmit operations on the given interval. For $G_{K_j}(T)$, as well as for $\rho_s(T)$, there are upper and lower boundaries; i.e. $infG_{K_j}(T) = minG_{K_j}(T) = 0 \leq G_{K_j}(T) \leq V_{K_j}^{\text{x(r)}} = supG_{K_j}(T) = maxG_{K_j}(T)$. In the ideal case, the value of $G_{K_j}(T)$ can be equal to the receive-transmit speed $V_{K_j}^{\text{x(r)}}$ of the information codes $x(r)$ of the channel K_j, from the RAM and the ED or from the ED and RAM:

$$\lim_{T_{K_j}^{\text{зпп}} \to T_{K_j}^{\Phi}} K_j(T) = V_{K_j}^{\text{x(r)}}.$$

The considered examples clearly show only some possibilities of using the proposed engineering approach in the analysis of CP and studying the properties of ICS for specific applications. However, they do not exhaust all its capabilities, which can be disclosed when considering other dependencies and indicators, introduced in accordance with the objectives of the ICS study.

For the fullest use of the capabilities of the engineering approach, it is necessary to know the structure of the ICS being studied and the peculiarities of its functioning at the HC level, which will make it possible to distinguish the lines and directions of the IS transfer among separate HC in this structure, and also to determine the types of homogeneous IS's transmitted in these backbones.

Thus, it is possible to formally describe any IS in the ICS and obtain the required expressions for calculating the integral and differential performance of individual HC and ICS in general. The analysis of the expressions, obtained as a result of the formalization of the IS for the parameters, dependencies and indicators considered, allows to determine the basic requirements for the selection of measuring means (MM), by means of which it is possible to obtain differential and integral IS statistics in ICS. First of all, it should be noted that most of these expressions contain parameters as components, characterizing either the number of transmitted information codes, or the time taken to transmit them, or both, i.e. the parameters $N_s^{x(r)}$ and $T_s^{x(r)}$ are basic and are used to determine the values of other parameters, dependencies and indicators. It follows that one of the main requirements for MM is the ability to measure various values of the parameters $N_s^{x(r)}$ and $T_s^{x(r)}$ for multiple HC systems when transmitting or receiving information codes $x(r)$. Since the transmission (reception) of $x(r)$ between the HC during the operation of the ICS is carried out at random intervals, the measuring device must record the start and end times of transmission (reception) of these codes; calculate the value $N_s^{x(r)}$ on each time interval and accumulate its total sum at all intervals; determine the duration of each interval and accumulate the values $T_s^{x(r)}$ as a sum of individual time intervals; provide the possibility of specifying different values of the measurement period T; differentiate the measured parameter values for various information codes $x(r)$. In addition, the MM should ensure, during the measurement of microscopic events (the parameters of the IS considered above) at the register level, high levels of accuracy, reliability and resolution, without introducing additional interference that could affect the results of the operation of the ICS. They should be convenient and simple in practical application, correctly interact with the ICS in the process of collecting, fixating and accumulating the values of the measured IS parameters.

4 Conclusion

The autonomous multichannel hardware measurers are the most suitable for the listed requirements, the use of which is most effective for obtaining differential and integral statistics of IS in ICS. However, modern ICS of domestic and foreign production are not equipped with such measurers, so it is necessary to solve a number of issues related to their development and manufacturing.

The proposed engineering approach makes it possible to establish simple relationships between the parameters of IS and the performance of individual HC's and ICS's as a whole, as well as to estimate the distribution of these streams between these components, necessary for the analysis of CP's and the study of ICS properties for specific applications.

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