System model the processing of heterogeneous sensory information in robotized complex

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Abstract. Analyzed the scope and the types of robotic systems consisting of subsystems of the form "a heterogeneous sensors data processing subsystem". On the basis of the Queuing theory model is developed taking into account the unevenness of the intensity of information flow from the sensors to the subsystem of information processing. Analytical solution to assess the relationship of subsystem performance and uneven flows. The research of the obtained solution in the range of parameter values of practical interest.

1 Introduction.
The modern stage of society development is characterized by the expansion of application fields of robototechnic complexes (RC) and technology. The basis for the structure of RK is a system of diverse sensors, performing the measurement, collection, formation and direction of the subsystem of information processing of different parametric form [1,2].

The most common in Kazakhstan are internal local area network (LAN) of the form "a heterogeneous sensors data processing subsystem". Such LVS are always an integral part of automated systems and Kazakhstan in different areas of arts activities: research; education; industry; economy; medicine; the social sphere [3–8].

In this formulation, important and urgent is to develop a mathematical model that allows to evaluate and formulate requirements to the parameters of the model elements of such a private LAN.

Theoretical part. The analysis of literary sources shows that in about-setitemnum plan, the basic elements of the internal LAN RK consist of the following main elements [2]:
1. Heterogeneous sources – sensors (sensors) i.e., the initial elements of the radiation data or information about the state or properties of a process, technology or RK.
2. Receiver (subsystem of information processing) of the initial elements included in the means of measurement and monitoring information and the feature space.

The processes of functioning of systems with such structural and functional organization most adequately describes the models and methods of Queuing theory [9].

Therefore, for solving the problem develop a model of the functioning of the internal LAN of Kazakhstan it is necessary to investigate the queueing system of type MP/M/1//N, where N elements
of the lower level in the form of working sensors initiate service requests with different intensity, i.e., as it is over-hanging on the type of sensor and solved RK at the moment of the task.

Graphs of the functioning of the LVS RK a closed type with multiple sensors having different intensity of information flow and a processing engine is shown in Figure 1.

![Graphs of the functioning of the LVS RK](image)

Figure 1. Graphs of the functioning of the LVS RK a closed-type sensors having different intensity of information flows: a) N=1; b) N=2; a) N=3.

Note that the solution for the model of type M/M/1//N, according to the classification of Kendall, i.e., with the same intensity of service is known and the difference of the proposed model consists of recording the fact of non-uniformity of generation of the information flow sensors of the lower level.

In the first stage, first decide the task for the special cases N=1, N=2, N=3 and try to identify patterns, which can be used to find a common solution.

Based on the graphs depicted in Figure 1 and describing the process of functional planning of such a system, for different occasions make a system of linear differential equations [10] that will move on to the differential. These equations have the following form.
For the stationary regime we get the following solutions:

\( N = 1 \):

\[
P_0 = S_0 = \frac{1}{\rho_1 + 1};
\]

\[
P_1 = S_1 = \frac{\rho_1}{\rho_1 + 1}.
\]

\( N = 2 \):

\[
P_0 = S_0 = \frac{1}{(\rho_1 \rho_2 + \rho_2 \rho_1) + (\rho_1 + \rho_2) + 1};
\]

\[
P_1 = S_1 = \frac{\rho_1}{(\rho_1 \rho_2 + \rho_2 \rho_1) + (\rho_1 + \rho_2) + 1}.
\]
where \( S_i \) is a discrete state Markov chain describing the functioning of the regulation of LVS RK;

**RK group of States**, which determines the probability of finding a system 
To the requests;

\[
\rho_i = \frac{\lambda_i}{\mu} - \text{utilization of the system i-stream applications;}
\]

\[
\lambda_i = \frac{1}{T_{cp_i}}(1) - \text{the intensity of the flow of applications from the i-sensor RK;}
\]

\[
\mu = \frac{1}{T_{cp}}(2) - \text{intensity of service requests in the engine.}
\]

The solution of the problem for cases \( N > 3 \) becomes much more complicated, however, analysis of 
the structural expression (1) allows to obtain a General formula for determining RK for any number of 
sensors having different intensity of the appearance of the queries [11]:

\[
P_0 = \left[ \sum_{k=0}^{N} \prod_{i \in N} \rho_i^{(M)} \right]^{-1}; \quad (2)
\]

\[
P_K = \begin{cases} 
  P_0 \prod_{i \in N} \rho_i^{(M)}, & 0 < K < N, \\
  0, & K > N,
\end{cases} \quad (3)
\]

where \( M = A_N^K \) – he number of placements of N by K;

\[
\prod_{i \in N} \rho_i^{(M)} - \text{the work of a group of parameters PI that are included in the M-accommodation.}
\]
The equation (2,3) is obtained by deduction based on the detection of naturally-STI in changing the coefficients in the equations and their extrapolation to the General case. Additionally, the accuracy and correctness of the obtained solution is checked Las by analyzing the condition \( \sum_{k=0}^{N} P_k = 1 \) on the grid of parameters whose values changed in the range of practical interest for this class of subsystems of the processing in RC. In this case, \( N = 1(1)100 \) and \( PN = 10^{-3}(10)103 \). Inspection of the expressions (2-3), are made nye by means of simulation, showed their accuracy and their applicability for the analysis of queueing systems of the closed type with various elements.

To assess the impact of the uneven information processing sensors the lower level to the time parameters of the processing subsystems will conduct a research of the solution. Thus comparable values for the utilization rate of system resources subsystem processing options with identical and different treatment times, but with equal total intensity of the stream of queries processed, i.e.,

\[
\lambda_{ob} = N \lambda \quad \text{for RK with the same sensors;}
\]

\[
\lambda_{ob} = \sum_{i=1}^{N} \lambda_i \quad \text{for RK with different sensor sources.}
\]

Analyze in the framework of the approach [12, 13] will change as the parameter \( \overline{L}_a (\overline{L}_a = 1 - P_0) \), defining bandwidth \( B = \mu \overline{L}_a \), in the framework of the proposed model. First of all, note that the same number of sensors and is equal to the total intensity \( \overline{L}_a \) will be different as it is possible to obtain a large number of values works \( \prod_{i=1}^{N} \rho_i^{(M)} \) when changing the parameters PI. So important is the determination of possible boundaries changes.

The maximum value \( \overline{L}_a \) accept in case of equality of intensity of all sources:

\[
\overline{L}_{a\max} = 1 - \left[ \sum_{K=0}^{N} \rho^K \frac{N!}{(N-K)!} \right]^{-1}. \tag{4}
\]

Minimal, if \( \rho_N \rightarrow \rho_{ob} \), \( a \sum_{i=1}^{N} \rho_i \rightarrow 0 \), i.e. when the intensity of one source is much higher than the total intensiveness of the rest. Then the expression for \( \overline{L}_a \) has the form:

\[
\overline{L}_{a\min} = 1 - \left[ \sum_{i=1}^{N} \rho_i \right]^{-1}. \tag{5}
\]

Consider the amount by which it is possible to change \( \overline{L}_a \). For this we introduce the function \( \delta(N, \rho_{ob}) = \overline{L}_{a\min} - \overline{L}_{a\max} \), reflecting the absolute deviation of the values \( \overline{L}_a \) in the case of \( N \) – sources with the same intensity and in the worst case with \( N \) – sources of varying intensity:

\[
\delta(N, \rho_{ob}) = \left[ \sum_{i=1}^{N} \rho_i + 1 \right]^{-1} - \left[ \sum_{K=0}^{N} \rho^K \frac{N!}{(N-K)!} \right]^{-1}. \tag{6}
\]

The value of the function \( \delta(N, \rho_{ob}) \) for different \( N \) is shown in Figure 2.
As $0 \leq T_a \leq 1$, it $\delta(N, \rho_{ob})$ a good illustration of the change $T_a$. For different $N$ it is possible to accurately find the maximum value of $\delta(N, \text{Rob})$ by determining the first derivative of expression (6) and then solving the resulting equation for $\rho$. However, because of the cumbersome decision appropriate to use numerical methods.

The analysis of graphs in Fig. 2 shows that the greatest discrepancies are observed $6 \cdot 10^{-3} \leq \rho_{ob} \leq 20$, where $\delta(N, \rho_{ob})$ varies from 0.05 to 0.35.

In $\rho_{ob} > 20$ and $\rho_{ob} \leq 6 \cdot 10^{-3}$ the differences are minor and do not exceed 12%. The observed increase in the discrepancy function $\delta(N \text{ Rob})$ as the number of elements, while at the same time the maximum moves to the left.

2 Conclusion
The studies show that the value of the parameter $T_a$ in the two-phase model of mass service closed-circuit, originating in matter from sensors with different intensity, with different parameters $N$, $\rho$, may be different from the known models by more than 35 %. Given the fact that the parameter $T_a$ directly determines the bandwidth of this structure, it is obvious that for the analysis of processes of functioning of the internal LAN of Kazakhstan it is necessary to use the developed model.

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