Assessment of Technical Means Quality Indicators for Smart Transport Systems

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Abstract. The purpose of this article is to show that it is necessary to assess the quality indicators for the technical means of smart transport systems. The quality of technical means, including smart transport systems, is associated with the selection of rational information processing technologies. Data in information systems is processed in different sections. The authors suggest an assessment technology for the operational quality of technical means of automated transport information systems. They identify the key quality indicators for the operation of technical means of information systems. The authors demonstrate that the operation of technical means can be characterized by the system task time, output data accuracy, and system implementability. They present the calculation of technical means quality indicators for smart transport systems.

1. Introduction
The selection of technical means is closely associated with the identification of operational quality parameters [1-3]. Data in automated information systems are processed in different sections. Different data processing sections are integrated into a single cycle by the process flowchart, and final statements about the required technical means can only be made after a comprehensive analysis of the entire process [4-6].

The correct problem statement requires a preliminary identification of operation quality indicators for the automated information system in question that would be further subjected to qualitative and quantitative assessments.

2. Materials and method
Key operating indicators for the technical means within an automated system include [7-10]: system task time, output data accuracy, and system implementability.

2.1. System task time
Information is discrete by nature. We can say that information is fractional, and a portion of information stands for a set of data recorded on a specific medium that simultaneously enters the section and is processed in it. As the data portion moves from one section to another, it may change. When information passes through the information system, we can identify the time which the portion in question spends at various sections.

The time various information portions spend at each of the sections is a composite of the waiting
time \( w \), processing time \( b \), and post-processing delay time \( f \).

To solve the problem, information systems must process the information in one or several sections, \( i \) is the specific section ID. Assume that the array of information processing sections is \( L \). In this case, \( L_k \) is a subset of sections where the information is processed to solve task \( k \). In this case, the total task time can be obtained from the following expression:

\[
z_k = \sum_{i \in L_k} \# z_{i,k} = \sum_{i \in L_k} \#(w_{i,k} + b_{i,k} + f_{i,k})
\]

(1)

where \( \# \) in \( \sum \) means that we need to consider the possibility of parallel information processing at different sections when summing up the values \([11-13]\).

Expression (1) provides a general task time (data portion processing time) formula for information systems. Some of the components may be absent from this expression depending on the specific information portions.

When selecting the technical means, it is necessary to require the following conditions to be implemented for each task:

\[
z_k \leq T^0_{i,k}, \quad k = 1, K
\]

(2)

where \( T^0_i \) is the set constant value; \( K \) is the number of various task types.

Values in expression (1) are generally random. Therefore, we assume that expression (2) is either a limitation for the mathematical expectation of the respective random values

\[
M(z_k) \leq T^0_{i,k}, \quad k = 1, K
\]

or a probabilistic limitation with a preset confidence level \( P^0 \) (can be different for various portions of information)\([14-17]\)

3. Results

3.1. Output data accuracy

Devices used in information systems tend to distort information.

Use \( \delta^r \) to describe the error in document \( r \) produced by the system in question \((R \) is the total number of generated documents). Value \( \delta^r \) includes the errors created by various factors

\[
\delta^r = \varphi(\delta^r, F = 1, 5),
\]

(3)

where \( \delta^r \) is the error occurring in the document in question due to factor \( F \).

When selecting the technical means, it is necessary to require the following conditions to be implemented for the generated document:

\[
\delta^r \leq \delta^r, \quad r = 1, R
\]

(4)

where \( \delta^r \) is the set constant value for each of the documents and \( \delta^r \) can be found using (3).

Values \( \delta^r \) and \( \delta^r \) are generally random. Therefore, we assume that expression (4) is either a limitation for the mathematical expectation of error values in the respective generated documents

\[
M(\delta^r) \leq \delta^r, \quad r = 1, R
\]

or a probabilistic limitation with a preset confidence level \( P^0 \) (can be different for various generated
For the sake of simplicity, we will link document index $r$ with index $k$ of the task during the implementation of which it was produced.

4. Discussion

System implementability. The requirement for the practical implementation of the system, for which the technical means are selected, is associated with some limitations. [17-20]

First of all, the technical means should be selected from the hardware types available (currently or by the time of system deployment). Developing technical means for the designed system is only acceptable as an exception because it is commonly more feasible to use mass-produced devices. Thus, we can use the hardware parameters from catalogs, brochures, and specifications when selecting the technical means.

If the automated facility is already equipped with some technical means, we have to assess the feasibility of their further use.

Under uneven equipment loading, the calculations must account for the type and number of relevant technical means available to organizations where they can be rented during peak loads to provide the system implementability.

Some implementability limitations are associated with the specific operational features of some functional groups of information system technical means. For instance, when information inputs in the system are associated with significant queueing times, the practical implementation of the system requires additional limitations to be imposed for the time spent by the data portion in question in the data collection section.

\[ M(t_{1:k}) \leq t^0_i \]

where $t^0_i$ is the set constant value or
\[ P\{t_{1:k} \leq t^0_i \} \geq P^0, \]

where $P^0$ is the respective confidence level.

Some data transfer sections operate in the denial mode: if all of the devices are receiving other information portions or are inoperable when the data portion transfer request is generated, this request will be denied. To transfer the portion in question, this request must be repeated. Sections like these generally have additional limitations for the probability of denial
\[ P^{\text{deac}} \leq P^0_{\text{deac}} \]

where $P^0_{\text{deac}}$ is the set constant value.

Information processing sections have limitations caused by the storage of information on specific memory devices.

As a rule, the RAM of computing systems have limitations like
\[ \sup_{\tau} \sum_{k \in \mathfrak{M}(\tau)} W^k(\tau) \leq W^{r(1)} n^{(1)}_w, \]

where $W^k(\tau)$ is the volume of RAM required for the processing of data portion $k$ at $\tau$;
$W^{r(1)}$ is the volume of one RAM device;
$n^{(1)}_w$ is the maximum number of simultaneously operating RAM devices.

Summing is performed for the data portion set $\mathfrak{M}(\tau)$ that is processed simultaneously at $\tau$ (set $\mathfrak{M}(\tau)$ – a function of $\tau$ – time), and the maximum is received from the entire period $T$ for system task
accomplishment.

Similar limitations may be made for the volumes of external memory devices with direct sampling

$$\sup_{\tau \in \mathbb{T}} \sum_{k \in \mathbb{Z}(\tau)} W_k^i(\tau) \leq W^{(1)}_i n_w^{(q)}, \quad q = 2, Q,$$

where \( q \) is the memory device type ID;
\( Q \) is the number of various external memory device types with direct sampling;
\( n_w^{(q)} \) is the maximum number of type \( q \) devices that can be used at \( \tau \) and the computer can make additional limitations for \( n_w^{(q)}, q = 2, Q, \) such as

$$\sum_{q=2}^{Q} n_q^{(w)} \leq N_w^{(q)},$$

where \( N_w^{(q)} \) is the maximum number of external memory devices (value \( N_w^{(q)} \) can change depending on the set of external memory devices, control devices, and switching gear used).

Devices with sequential sampling devices have a specific feature: when the memory available on a device is insufficient to store the entire required data portion (array) at once, only a fraction of the information is sent to the device to be processed in the first place. The remaining information can be sent to the device when the previous data are processed. Therefore, there is a limitation for the number of devices used when the system implemented uses sequential sampling:

$$\sup_{\tau \in \mathbb{T}} \sum_{k \in \mathbb{Z}(\tau)} m_k^{(e)}(\tau) \leq M^{(e)}, \quad g = 1, G,$$

where \( m_k^{(e)}(\tau) \) is the number of type \( g \) arrays used in the processing of data portion \( k \) at \( \tau \);
\( g \) is the type of machine medium used in the array in question;
\( G \) is the number of various external device types;
\( M^{(e)} \) is the maximum number of type \( g \) devices that can be used in the system.

Some additional limitations are possible

$$\sum_{g=1}^{G} M^{(e)} \leq M_G,$$

where \( M_G \) is the total number of external memory devices with sequential sampling that can be connected to the computing system (may vary depending on the set of external device types used).

To assess the quality of technical means operations in transport information systems, it is necessary to consider all of the quality indicators mentioned in the research. It is necessary to assess the quality indicators for the operation of the technical means of transport information systems to improve data accuracy and reliability. The procedure described can be used for designing automated transport information systems.

5. References

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