MSC 68U20 DOI: 10.14529/jcem240206

COMPUTER TECHNOLOGIES FOR INFORMATION SUPPORT OF AUTOMATED SYSTEMS

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The article shows the relationship between the quality of information support and the efficiency of functioning of automated systems, and identifies the main directions for focusing the efforts of developers when creating and modernizing computer technologies for collecting and processing information. Conclusions from a system analysis of the state of information support for automated systems are presented, and the features of the methodological approach to its synthesis are shown. The tendency to increase the role of a new component of the machine information base – an information resource – for the effective use of automated systems is characterized. A promising direction of activity to improve the efficiency of automated systems has been identified.

Keywords: automated system; computer technology; information support; information base; information resource.

Introduction

One of the key aspects of increasing the efficiency of almost all areas of labor productivity in modern conditions is the use of computer technologies for collecting and processing information, artificial intelligence technologies and digitalization of all spheres of human activity [1, 2]. This circumstance necessitates the development, modernization, implementation and application of modern automated systems (AS) [3].

The operating efficiency and readiness for use of any modern AS is determined, among other things, by the quality of its supporting subsystems [4]. Currently, experts identify nine main types of AS support: technical, mathematical, software, information, linguistic, organizational, legal, methodological and ergonomic. At the same time, according to leading experts in the field of business process automation, the effectiveness of automated systems is largely determined by the quality of their information support (IS) [5, 6].

At the same time, the experience of designing AS shows that the main attention of development teams is currently paid to issues of technical, mathematical and software types [7]. According to experts, the costs of these types of support amount to up to 80%, and the remaining types, including AI, are developed on a residual basis [8]. This often leads to the use of outdated approaches and methods for organizing information about the subject area being automated in systems and reducing the efficiency of not only the automated system, but also labor productivity in general.

The study of this problem situation requires, at the initial stage, an analysis of the content of the IR of modern AS in order to identify current trends in the forms and methods of organizing the collection and processing of information.

1. Contents of Information Support for Automated Systems

In accordance with state standard of the Russian Federation R-59853-2021, information is understood as information ordered by structure and forms of presentation intended for use in an automated system, as well as a set of methods, tools and computer technologies for its generation, storage, updating and distribution.

IR activities are divided into stage types:

1. Development (selection) of methods and means for generating, storing, updating and distributing information in the AS, ensuring its interoperability;

2. Organization of the AS information base.

The analysis showed that currently, when developing almost any AS, the activity within the first stage comes down to setting and solving classical problems of multi-criteria selection (optimization) from existing technological solutions (data presentation formats, database management systems, data storage media and others).

In general, the multicriteria selection model can be presented as follows:

1. Many possible solutions (alternatives) to the problems of the first stage:
   $Y_m = \left\{y^1, y^2, \ldots, y^k\right\}; m, k = \overline{1, N}$, where y^k is the considered technological option for implementing the m-th task;

2. Criteria (objective functions): $F = \{f_1, f_2, \ldots, f_z\}$, $z = \overline{1, N}$, where f_z is the z-th optimization criterion (for example, ease of operation or price);

3. Preference relation $\succ_{Y_m}$, defined on the set of possible solutions Y_m.

Before considering the content of the second stage, it is necessary to define the concept of the AS information base. In accordance with [8], the information base is understood as a set of ordered information used in the operation of the AS. At the same time, the formation of an AS information base implies [9–11]:

1. Off-machine AI – formalization of the automated subject area, in order to determine the input and output documents of the traditional document flow of all business processes, their relationships, as well as taking into account the requirements of the regulatory framework regulating the subject area under consideration;

2. In-machine AI – development (selection) of approaches to structuring information, ways of organizing information about the entities of the subject area being automated, in an optimal (rational) form for the AS.

2. Features of Off-Machine Information Support

The primary and most important for the formation of the AS information base is off-machine information. It allows, through a formalized description of automated business processes, to establish the composition and structure of information necessary and sufficient for the implementation of technological management cycles. In addition, it implies the creation (selection) of a unified system of documentation and classification

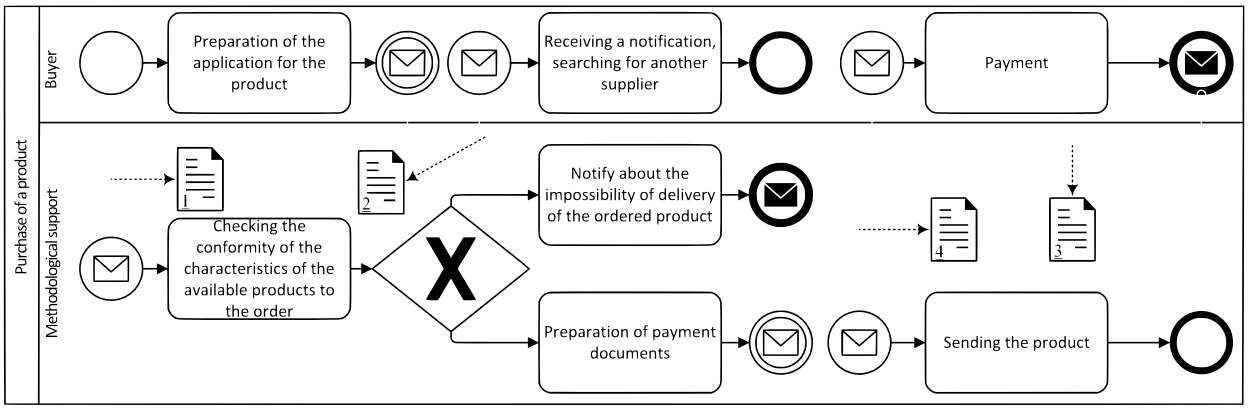


Fig. 1. BPMN model of the business process "Ordering goods"

based on the selected properties of physical entities described in the document flow – details or their combination – indicators [9, 12].

The result of out-of-machine IO is an out-of-machine information base of the AS, which is a set of documents intended for direct perception by a person without the use of computer technology [4] and which is the basis for the subsequent development of the structure and composition of information directly stored in the AS (in-machine IO) – a machine information base.

Currently, functional and process modeling methods are widely used to analyze automated business processes: Structured analysis and design technique (SADT (IDEF0)), Integrated DEFinition for Process Description Capture Method (IDEF3), Data Flow Diagrams (DFD), Architecture of Integrated Information Systems (ARIS), Business Process Model and Notation (BPMN), Unified Modeling Language (UML).

At the same time, to identify the features of the subject area being automated, and most importantly, to understand the genesis of circulating information, process approaches are most preferable. With a process approach, the main focus is on what needs to be done to obtain the result of interest, that is, the emphasis is shifted to the sequence of actions itself.

Fig. 1 shows an example of a process model of the abstract business process "Ordering goods", implemented in BPMN notation.

3. Features of Analyzing the Content of Documents That Ensure the Implementation of Business Processes

The next stage of activity in the formation of an off-machine information base is an analysis of the content of established documents that ensure the implementation of the business processes under consideration (marked with numbers 1-4 in Fig. 1). At the same time, the analysis is based on the process of identifying logically indivisible elements in documents that describe a specific property or group of properties of the displayed object (phenomenon) – details. In addition, their relationships are established, which achieves the structuring of information [13, 14].

In the practice of automated data processing, groups of details – indicators –

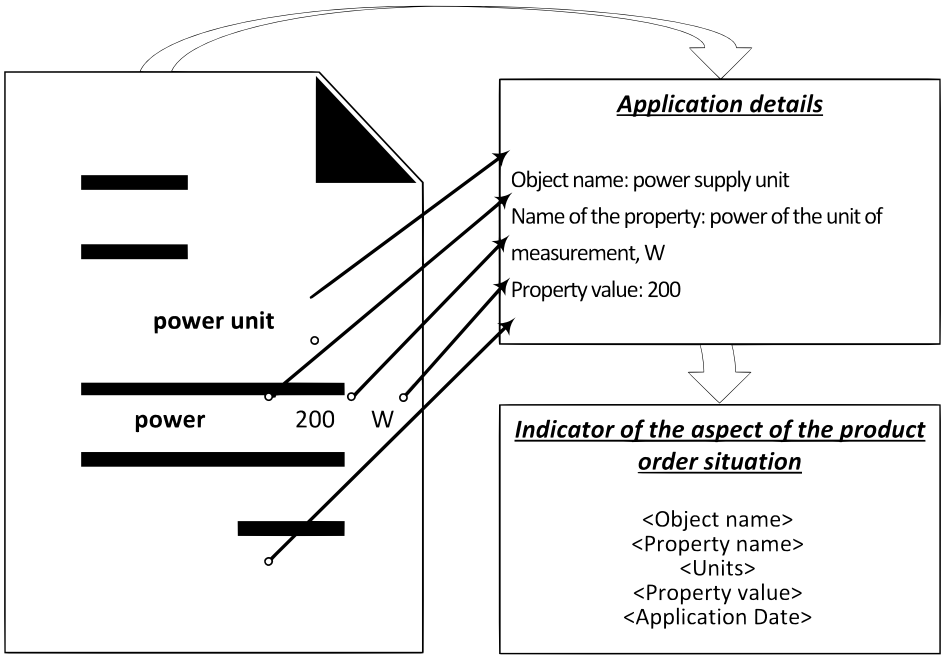
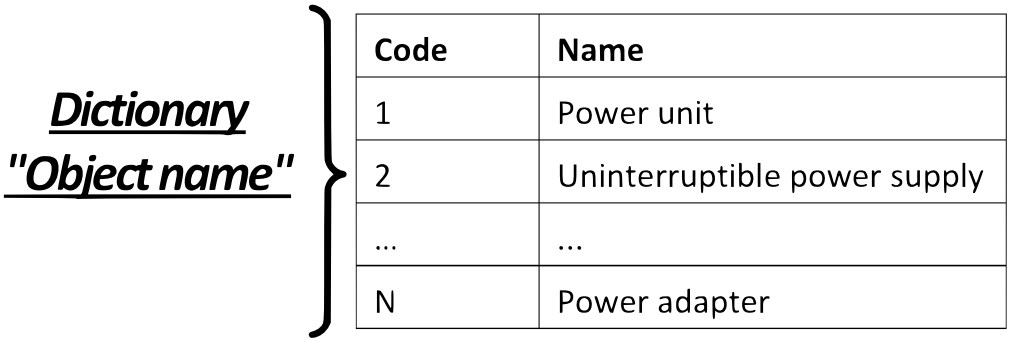


Fig. 2. Structure of connections between the categories "document-attribute-indicator"



Code	Name
1	Power unit
2	Uninterruptible power supply
...	...
N	Power adapter

Fig. 3. Example of a code entity "Product color"

are widely used to describe the qualitative or quantitative properties of the displayed entity (object, phenomenon). The relationship between the primary document-attribute-indicator categories is presented in Fig. 2. It should be noted that at present, technologies based on machine learning are increasingly being used every year to classify and extract details from information circulating in an automated subject area [15, 16].

Almost any business process is characterized by the "movement" of entities from stage to stage, which also implies continuous documentation of changes in their states. In the above example, "Ordering a product" is, for example, the capacity of the product being ordered. As a result, there is a possibility of a mismatch between the writing of the "unit of measurement" (for example, kW) and the "property name" (0, 2) at each subsequent stage of the process, which can ultimately lead to errors. In order to prevent such situations, as a rule, a system of classification and coding of information is developed, Fig. 3.

At the final stage of off-machine information, regulatory and reference information is

generated, including regulatory documents regulating the subject area, as well as some documents selected at the analysis stage.

Thus, the activities of off-machine AI include: studying the specifics of the subject area; analysis of the existing document flow system and identification of details (indicators) in circulating documents, as well as the selection (development) of unified forms of AS documents; creation of a system for classifying and encoding information for details of general use; documenting the results obtained.

4. Features of In-Machine Information Support

The next stage in the development of AS IO is in-machine IO, which implies a set of measures for organizing the details of the subject area in the form of data that is subject to subsequent processing in the AS. The result of the synthesis of in-machine IO is a specially organized machine information base, which is a set of information used in the AS in electronic form [4]. The purpose of in-machine information is high-quality information support for all technological cycles implemented by the AS.

Currently, machine databases are organized in two ways, in the form of a set of local files supported by special software and an integrated database based on the use of database management systems (DBMS). At the same time, the main criteria for organizing a machine database remain:

1. Completeness of data presentation;
2. Independence of the array structure from the software that uses them;
3. Speed and reliability when performing operations to search, process and present data to the user.

A file, as a form of organizing information storage, is a collection of records of a homogeneous structure, consisting of a set of fields of a given format. With this approach to organization, the machine information base of the AS is a set of unrelated files with a single-level structure. The main advantage of such an organization model is that due to the adaptation of the data structure of each file to specific tasks, in most cases, the shortest data processing time is ensured [8, 17]. However, the difficulties of organizing local files, expressed in frequent duplication of data, and most importantly, in the lack of flexibility in accessing information, neutralize this advantage. In this regard, this method of organizing the machine base is practically not used at present.

In-machine AI of modern AS implies the design of a database that provides storage of data details in accordance with schemes corresponding to business process models. In this case, data management, including its creation and maintenance, is carried out using special software – a DBMS.

Thus, the result of working through all stages of the AS IO is the provision of data necessary for the implementation of the system's technological cycles, which ensures the effectiveness of solving the target tasks of the IO functioning as a whole.

However, in the process of development of modern society and AS, AI developers are increasingly faced with a situation in which, in the process of analyzing an automated subject area, it is almost impossible to extract details from circulating documents, and as

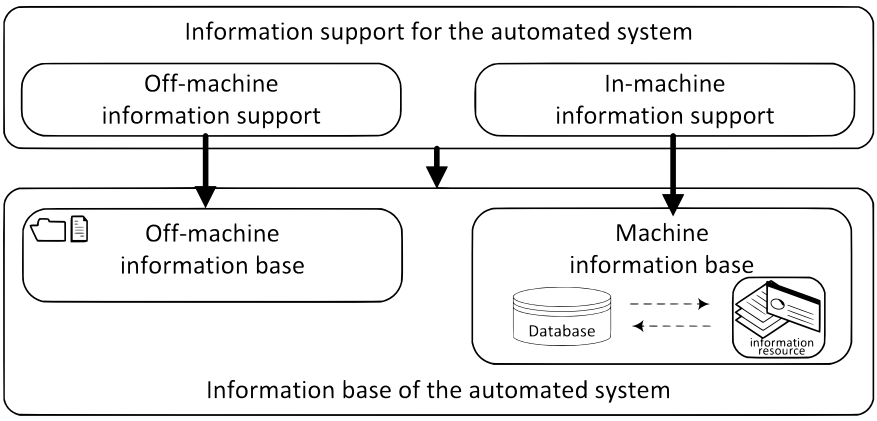


Fig. 4. Structural diagram of information support of the AS

a result, it is problematic to organize the information of the subject area in the form of an integrated database.

This problem is mainly typical for automated information systems for scientific research, information and reference systems, decision support systems and automated library and information systems. The specificity of circulating information in such systems implies the formation of an additional resource within the machine information base, called information. In accordance with [4], an information resource (IR) is understood as a set of identifiable information in an AS that has meaning. The place of IR in the structure of the IA AS is presented in Fig. 4.

A characteristic feature of the IR is its continuous filling during the operation of the system in order to meet the information needs of users. This circumstance determines the dependence of the effectiveness of the functioning of ASs, which are based on certain IRs, on two aspects: the quality of the available IRs and the efficiency of searching and providing the requested information [3,18, 19].

It should be noted that the quality of searching and providing information at the time of application of the system should be considered as a constant, since the corresponding mechanisms and technologies are incorporated into the AS at previous stages of the life cycle. At the same time, the quality of the IR is a variable value and requires continuous analysis and management in order to ensure the required efficiency of the AS.

Taking into account the above, the set-theoretic construction defining the information base of the AS will have the form:

$$\Omega = \langle A, B \rangle ,$$

where $A = \{a_1, a_2, \ldots, a_r\}$ is many documents underlying the automated subject area $\left(r = \overline{1, N}\right)$, specified in accordance with the rule:

$$A = \{a_r \,|R_A = 1\} ,$$

$$R_A\left(a_r\right) = \begin{cases} 1, & \text{if the document is used;} \\ 0, & \text{other wise.} \end{cases}$$

Set $B = \langle X_1, X_2 \rangle$ defines the machine information base, where $X_1 = \{x_1{}^1, x_2{}^1, \ldots, x_v{}^1\}$ is set of records in the database; $X_2 = \{x_1{}^2, x_2{}^2, \ldots, x_l{}^2\}$ is a lot of information materials in the IR.

Conclusion

Thus, at present, there are practically no approaches to the formation of IR, and the requirements for the content of documents for the AS being developed regarding them have not been formulated. Taking into account the above, it seems advisable to create unified approaches to the formation and management of various IR, which will require at the initial stage the development of an appropriate classification system.

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Received May 09, 2024

УДК 004.9 **DOI: 10.14529/jcem240206**

КОМПЬЮТЕРНЫЕ ТЕХНОЛОГИИ ИНФОРМАЦИОННОГО ОБЕСПЕЧЕНИЯ АВТОМАТИЗИРОВАННЫХ СИСТЕМ

М. А. Прохоров, Д. С. Тобин

В статье показана взаимосвязь качества информационного обеспечения и эффективности функционирования автоматизированных систем, определены основные направления сосредоточения усилий разработчиков при создании и модернизации компьютерных технологий сбора и обработки информации. Представлены выводы из системного анализа состояния информационного обеспечения автоматизированных систем, показаны особенности методологического подхода к его синтезу. Охарактеризована тенденция повышения роли новой составляющей машинной информационной базы – информационного ресурса – для эффективного применения автоматизированных систем. Определено перспективное направление деятельности по повышению эффективности функционирования автоматизированных систем.

Ключевые слова: автоматизированная система; компьютерная технология; информационное обеспечение; информационная база; информационный ресурс.

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Поступила в редакцию 09 мая 2024 г.