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Synthesis of an Electronic Document Management Model for Technical Documentation

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Abstract*: The article examines the features of electronic document management of technical documentation of railway automation and telemechanics. The article deals with the problems of synthesis of mathematical models of electronic document flow for technical documentation of road automation and telemechanics. For this purpose, a survey of the real processes of creating, checking and using technical documentation was carried out on the basis of the process of accounting and control of railway automation and telemechanics devices, which allowed us to identify the structural scheme of the formalized model of technical documentation. A model of electronic document flow of technical documentation, created using the mathematical apparatus of finite automata, is constructed. A block diagram of the automatic model of technical documentation has been developed. The proposed block diagram of the formalized model of technical documentation consists of matrices of external micro-operations, internal micro-operations, and code creation for the following micro-components. The number of internal States of the firmware automaton is fully determined by the number of elements of logic circuits of algorithms. The size of the matrices depends on the number of operators and logical conditions in the logic schemes of the algorithms. The size of the matrices depends on the number of operators and logical conditions in the logic schemes of the algorithms. The application of the proposed methodology for building a model of technical documentation allows us to develop reliable application software for solving the problems of operational document management of railway automation and telemechanics.

Keywords*: electronic document management of technical documentation; model of electronic document management of technical documentation; formal presentation of technical documentation; technological process of accounting and control of railway automation and telemechanics devices; logic algorithms; block diagram of an automaton model of technical documentation.

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I. INTRODUCTION

The traditional way to automate electronic document management of technical documentation (EDMTD) is that the development of software gradually changes to the background mode, since even minor changes in the transport scheme and technological process mean the need to reprogram the application and consume more amount of time and money. As a result, there will be no time to update appeals, based on changing conditions and requirements of railway transport [1-3]. Actively developing systems associated with enterprise automation require a large number of trained personnel due to the high complexity. In addition, the number of qualified specialists in the field of automation is growing insufficiently fast [4]. Thus, the task is to create an easy-to-use, reliable automation tool, in the arsenal of which there are not only tools for describing a business process, but also its implementation. The possibility of implementation is important, since a pure descriptive tool is interesting only from the point of view of the analysis of technological processes and can be used only as part of a technical task when performing a specific model of the work process [5, 6]. EDMTD modeling is presented in the works of both Russian [7-12] and foreign authors [13-18].

Based on the logic schemes of algorithms (LSA) developed in the papers [19-21] for the process of accounting and control of railway automation and telemechanics devices (CARCD), this article presents a block diagram of an automatic model of technical documentation (TD), microcommands are formed according to the logic diagrams of algorithms TD, the problems of simplifying the structure of the automaton of the CARCD process are considered.

The purpose of this work is to describe and define an automated workflow model. EDMTD is considered as an object of modeling. To implement the model, an approved machine of the theory of automata will be used, adapted to modern programming technologies. The task of creating and implementing EDMTD is very urgent today. Significant financial, material and time resources are spent at enterprises and organizations of the railway to solve this problem.

II. SYNTHESIS OF AN ELECTRONIC DOCUMENT MANAGEMENT MODEL FOR TECHNICAL DOCUMENTATION BASED ON AN ABSTRACT FINITE STATE MACHINE

The most effective solution to the problems of automation of the CARCD process can be achieved by formalizing and applying mathematical methods to optimize coordination of interaction.

A number of methods are known for identifying the functioning algorithms of complex systems, namely: the method of simplifying the work [22]; drawing up structural informational-temporal schemes [23], flowcharts and organigrams [24]. The essence of these methods lies in the operational recording and analysis of the investigated process. The common drawbacks of these methods from the point of view of the CARCD study are: a limited set of conditional designations of operations; the complexity, and for a number of methods [25] and the impossibility of displaying the parallelism of the processes of CARCD, the complexity of filling out the survey forms.

There are languages for the direct description of discrete processes, which include Petri nets [26], logic circuits of LSA algorithms [27], logic circuits of requirements [28], parallel logic circuits of algorithms (PLC) [29].

CARCD taking into account the parallelism of processes can be considered as a stationary dynamic system with discrete time. According to [24], such a system is an automaton. Thus, it is advisable to use the methods of the theory of automata to simulate the functioning of the CARCD process.

The automaton approach [19] is to display the process as a mutual automation system (one automaton is placed in one or several states of another automaton) with the possibility of a call (one automaton is called by a certain event from the output state generated during the passage of another automaton) by exchange messages (one machine receives a message from another) and status (one machine checks the status of another machine). The internal organization of the process can be described by a sequence of events [20]. The number of machines installed in internal states is not limited by the depth of positioning. This representation allows a more compact description of the life cycle of a program, module, and in our case, the AP or the CARCD process. In turn, a compact presentation improves the look.

As a simulated object EDTD railway automation. The formulation introduced in [20, 21] is used as the basis for the automaton model.

Formally, the EDTD process is presented in the form of three limited sets and interconnections of the elements of this set [6]. The mathematical representation of this process is given in the following form

$$D_T = \{U, P, F\} \qquad (1)$$

here D_T is a formal representation of EDMTD; U is the set of participants; P is the set of processes; F - state of the TD with a range of actual values.

A limited set of real participants in the working process is established, P - in the revised system of the working process is defined as a limited set of processes performed by participants. F are the limited states that can be accepted by the TD after performing the procedures from P by the participants of the indicated set U.

Using the theory of automata [30-33], will be determined the automaton that executes the EDMTD model.

S (many states) is the set of all states that can be accepted by a document as part of a simulated workflow. Using the formulated notation from [6], this definition will be written as follows: $\{S\} \equiv \{F\}$.

Initial states refer to many states as a whole. s_0 is the initial set of states S. Therefore, in the framework of the proposed model $\{S\} \equiv \{F\}$, s_0 can be considered a subset of $\{F\}$.

Will be defined the relationship of the set of processes P from the definitions of EDMTD and the set of transition functions F_p. When constructing a model of an automaton model, the corresponding elements of the set: $\{F_p\} \equiv \{P\}$ to determine the set F.

In the described model, identification is established between the alphabet of the EDMTD automaton and the set of participants: ($\{A\} \equiv \{U\}$).

After synthesizing the model $\{U, P, F\}$, will be obtained the automaton model of EDMTD, which is defined:

$$M = (A, S, Z, s_0, F_p, E) \qquad (2)$$

here A is the input alphabet; S is the internal alphabet; Z is the output alphabet; s_0 is the initial status; H is the transition function defined by the transition table and denoting two sets $A \times S \to S$; E is the exit function defined by the exit table and denoting two sets $A \times S \to Z$.

For this example: $A = \{a, b\}$; $S = \{1,2,3\}$; $Z = \{0,1\}$; $s_0 = 1$; $F_p = \{1,1,1\}$; $E = \{2,2,2\}$.

Application of the presented model allows us to combine the approach in the development and use of EDMTD systems. The introduction of the EDMTD system will make the process of storing TD more transparent and predictable, and reduce the personal influence of executive staff on the final result.

III. DEVELOPMENT OF A BLOCK SCHEME OF AN AUTOMATON MODEL OF TECHNICAL DOCUMENTATION

On the basis of a microprogram machine (MA), a block diagram of a formalized TD model has been developed.

Based on the MA, the Wilks-Stinger scheme was implemented, which is used when there are no strict requirements for the speed of machine control in the synthesis of microprograms with the least control [34].

The proposed structural diagram of the formalized TD model consists of matrices of external micro-operations $M1$, internal micro-operations $M2$, code creation for the following micro-components $M3$. The presented model has become a new system paradigm for the representation of TDs [35, 36].

Each external micro-operation $Z_{V_{qg}}$ is a control operator, and the internal one $Z_{\alpha_{qg}}$ is a control logical α_{qg} condition that checks a condition whose values are fulfilled ($\alpha_{qg} = 1$; marked with a + sign) or non-fulfilled condition ($\alpha_{qg} = 0$; marked with a - sign).

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On the structural diagram, a circle denotes a circuit that serves to query the value $Z_{\alpha_{qg}}$ of the condition it is checking (Fig. 1).

Firmware, i.e. the sequence of microoperations is conveniently described in the language of LSA, and external microoperation V_{qg} is associated with the operator $Z_{V_{qg}}$, and internal microoperation α_{qg} is associated with the logical condition $Z_{\alpha_{qg}}$.

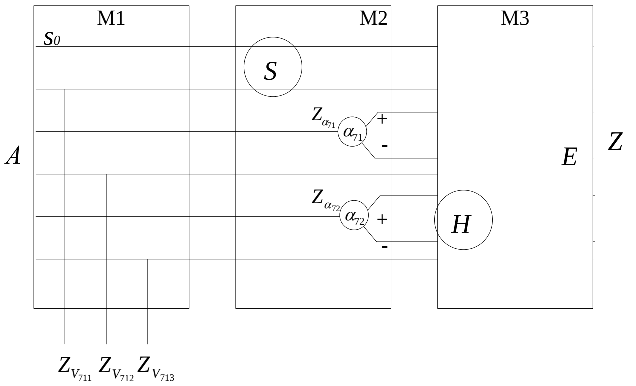

Fig. 1. Block scheme of a formalized TD model

When performing this operation, each micro-command includes only one micro-operation (external or internal) and includes only one operator or logical condition during each microtact. The number of internal states of MA is completely determined by the number of LSA elements. The size of the matrices *M*1 and *M*2 depends on the number of operators and logical conditions in the LSA. In the specific case, when only operators enter the LSA, the matrix *M*2 is absent. In this case, successive microcommands are generated each time in the *M*3 matrix.

If there are logical conditions in the LSA, the matrix *M*2 is needed, in which they are formed $Z_{\alpha_{qg}}$. If the value checked in $Z_{\alpha_{qg}}$ the logical condition (if it enters the LSA without inversion), the order of execution of the LSA elements is violated. Then, in *M*3, the necessary number of micro-commands must be formed in order to correctly perform LSA.

If will combined a separate micro-command with each element of the LSA, even a very simple algorithm requires that MA fulfill a large number of internal states. At the same time, there is no need to distinguish the internal position for each LSA element. Some external microoperations may not be performed sequentially, but simultaneously in a single microtact. This occurs when the operator performing operations on the corresponding microtacts can work in parallel. LSA statements executed simultaneously are not related to the internal state of a single MA statement. This minimizes the number of internal states of MA. The combination of individual microoperations over time leads to an increase in speed, since the number of microtacts required to execute the algorithm decreases.

Simplification of the MA scheme can be obtained by simultaneously performing external and internal microoperations. Then the number of microcommands of MA will be determined not by the number of LSA elements, but by the number of groups of simultaneously performed microoperations. Consider the LSA technological process of accounting and control of railway automation and telemechanics devices A_T, which includes planning and repair of equipment, control of reception and storage, as well as the movement of devices in the repair and maintenance department:

$$\begin{aligned} A_T = {} & V_0 V_{711} V_{712} V_{713} V_{714} \downarrow^{717} V_{715} V_{716} V_{717} \downarrow^{715} \\ & V_{718} \alpha_{711} \uparrow^{711} V_{7110} V_{7111} \overline{\alpha_{712}} \uparrow^{712} \downarrow^{711} V_{719} \omega \uparrow^{715} \\ & \times \downarrow^{712} \downarrow^{714} V_{7115} \alpha_{713} \uparrow^{713} V_{7116} \alpha_{714} \uparrow^{714} V_{7117}\, \omega \\ & \uparrow^{716} \downarrow^{713} V_{7118} \omega \uparrow^{717} \downarrow^{712} V_{7112} V_{7113} V_{7114} V_k \end{aligned} \quad (3)$$

The CARCD process is presented in the LSA language [37, 38]. The main elements are the operators $V_{qg}, q = \overline{1, Q}, g = \overline{1, G}$ that correspond to the elementary actions of the process, logical conditions $\alpha_k, k = \overline{1, K}$ - the probability of their fulfillment depends on the current state of the process CARCD, represented by arrows $\alpha_k \uparrow^p, p = \overline{1, P}$, where p is the index of the arrow.

Here can distinguish 6 groups of simultaneously performed microoperations:

$$\begin{aligned} A_T = {} & \underbrace{V_0 V_{711} V_{712} V_{713} V_{714} \downarrow^{717} V_{715} V_{716} V_{717} \downarrow^{715} V_{718} \alpha_{711}}_{1} \\ & \underbrace{\uparrow^{711} V_{7110} V_{7111} \overline{\alpha_{712}} \uparrow^{712} \downarrow^{711} V_{719} \omega \uparrow^{715}}_{2} \\ & \times \underbrace{\downarrow^{712} \downarrow^{714} V_{7115} \alpha_{713} \uparrow^{713} V_{7116} \alpha_{714}}_{3} \uparrow \underbrace{{}^{714} V_{7117}\, \omega}_{4} \\ & \uparrow \underbrace{{}^{716} \downarrow^{713} V_{7118} \omega}_{5} \uparrow \underbrace{{}^{717} \downarrow^{712} V_{7112} V_{7113} V_{7114} V_k}_{6} \end{aligned} \quad (4)$$

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It follows from (1) that MA will have six internal states. The *M*3 matrix in Fig. 2 is constructed when compared with microcommands 1, 2, 3, 4, 5, 6 of the code combinations 001, 010, 011, 100, 101, 110, respectively.

Thus, will be examined the method of phasing the micro-commands in stages, and as a result will be switched from the micro-command, which includes only one external or internal micro-operation, to the micro-command, which includes the entire group of external and internal micro-operations. To form such microcommands, a firmware should be implemented in addition to the LSA, providing information on the possibility of simultaneous operation of various operators and the distribution of offsets for each operator. Obviously, the operator V_{qg} and the logical condition α_{qg} cannot be included in one micro-command if the value can be changed by the operator V_{qg} . The task of forming the smallest possible number of LSA microcommands is complex.

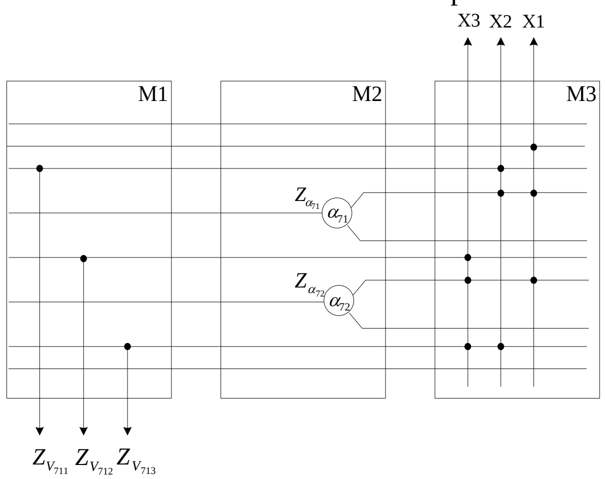

Fig. 2. The structure of the matrix *M*3

When considering various possible ways of constructing an MA circuit, it is considered that only one algorithm is implemented. However, a software control method is used precisely when several different algorithms need to be implemented in the machine.

The structure of the MA transition graph will largely depend on the choice of microcommands when comparing internal states with microcommands.

A special requirement is the development of methods that allow to minimized and encoded the machine, taking into account various requirements.

IV. Conclusion

The article proposes a method for constructing a structural diagram of a formalized model of TD microcircuit formation, effective for solving electronic document management tasks [39, 40].

The presented model can be used not only for the automation of CARCD processes, but also for electronic document management processes in general. The application of the proposed methodology for constructing the TD model allows the development of reliable application software for solving operational document management tasks.

The proposed structural diagram of a formalized model of TD takes into account matrix external micro-operations, matrix of internal micro-operations, as well as matrix code generation the following microcommands.

The methods of forming the TD model presented in this article are promising for solving the problems of electronic document management.

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