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Important Principles Of Innovative Reforms In The Process Of Electronic Document Management In Railway Automation And Telemechanics

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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 description of electronic document flow of technical documentation of railway automation and telemechanics. For this purpose, a survey of the actual processes of creating, checking and using technical documentation was performed on the example of maintaining custom specifications for automation and telemechanics systems, which allowed us to identify document flow scenarios, as well as protocols for the properties of technical documents. The method of creating a model of electronic document flow of technical documentation based on the graph theory apparatus is developed. To set the matrix form of document flow representation, it is proposed to use a set of flat rectangular matrices, each of which represents the state of the system in some discrete unit of time. The resulting incident matrices determine the graph model of the document flow of the process under consideration, and the set of these matrices sets all possible scenarios for the movement of documents in the process, describes all possible document States, and determines possible participants. The use of the proposed method for constructing a mathematical model based on graph theory allows us to develop reliable application software for solving problems of operational document management of technical documentation.

KEYWORDS

Electronic document flow of technical documentation, graph theory, model of electronic document flow of technical documentation, formal presentation of technical documentation, technological process of maintaining custom specifications of railway automation and telemechanics, matrix of incidents of electronic document flow of technical documentation

INTRODUCTION

Currently, the most complex tasks are being solved in railway transport using modern information technologies. Microprocessor systems are used to manage and centralize stations and stages. Intensive work is continuing on the transfer to electronic document management in parallel with the traditional paper document management. In Uzbekistan, there is currently a definition of this term at the legislative level [1].

The issues of formalization of electronic document flow of technical documentation (TD) of railway automation are considered in works [2-9], however, the task of clearly formalizing the concept of "electronic document flow of technical documentation" and creating a model of technological processes of railway automation and telemechanics, as well as using existing information technology achievements to solve management problems remains urgent.

To create a model of electronic document flow of technical documentation (EDTD) for signaling, centralization and blocking devices, a survey of the actual processes of creating, checking and using technical documentation in automation and telemechanics systems was performed. This allowed us to identify document flow scenarios and property protocols for technical documents.

This article discusses a new approach to creating models of technical documentation workflow based on the graph theory apparatus. Methods for defining sets for the developed model are described, and a document flow algebra using graphs is proposed.

GENERAL PROVISIONS

To build a graph model, need to defined a certain set of data that will be accepted by the basis. For a graph model, the data must be discrete and assume varying degrees of connectivity. The notation introduced in the paper is used as the basis for the graph model under consideration [2].

Formally, the EDTD process is represented as three finite sets and links of elements of these sets to each other. The mathematical notation of this process is represented as a triple

$$D_T = \{Y, P, F\}$$

where D_T – a formal model of electronic document flow of technical documentation; *Y* - a set of participants; *P* - a set of processes; *F* – a set of TD States with acceptable areas of values.

The set *Y* is defined as a finite set of actual document flow participants, and P is defined as a finite set of processes that are performed within the document flow system under consideration by participants from the set *Y*. *F* is a finite set of States that can accept TD after executing processes from the set *P* by participants from the set *Y*.

When building a graph model of the TD workflow, it is proposed to use the following method for displaying the TD workflow with graphs. To set the vertex set of a graph use the number of possible States of Edges of *F*. The edges of the graph will be set by using a variety of processes P and installed this according so as to fulfill the following rules:

- One node of the graph corresponds to one and only one element of the set *F*;
- One edge of the graph corresponds to one and only one element of the set *P*;
- One element of the set *F* corresponds to one and only one vertex of the graph;
- One element of the set *P* corresponds to one and only one edge of the graph.

Such an identical mapping of the sets of States *F* to the set of vertices *v* and the sets of processes *P* to the set of edges *e* can be mathematically defined as follows: for any *i*, the statement is true

$$v(i) \leftrightarrow F(i) \text{ and } e(i) \leftrightarrow P(i),$$

where $i \in I,\ I = 1,2,3,\ldots, n$.

That is, two paired grammars are defined – the first grammar for establishing the translation of *F* to *v*, and the second grammar for establishing the translation of *P* to *e*.

Thus, the relationships between vertexes correspond identically to the relationships of States of the modeled workflow. After implementing the sets of processes *P*, the States *F* of the technical documentation change. In a workflow graph, the vertices of a graph connect edges if and only if the corresponding state vertices are connected by an action corresponding to the edge, i.e.

$$e = \begin{cases} e, \text{ if the edge exists;} \\ 0, \text{ if the edge is missing.} \end{cases}$$

The direction of the edges is set in such a way as to display the logic of the sequence of changing document flow States. A vertex *i* is an incoming vertex for a vertex *j* through an edge *k* if and only if the state *i* changes to the state *j* after the action *k* is performed. Thus, the States *y*1, *y*2,..., yn are mapped to the vertices of the graph *v*1, *v*2,..., vn and each pair of vertices v_i and v_j is connected by an edge e_{ij} going from v_i to v_j if and only if state v_i is the input state for v_j.

To get a clear description of various structural properties of document flow, it is useful to introduce a number of concepts defined and widely used in graph theory into the graph model. The collection of a non-empty set *V*, an isolated set *E* (possibly empty), and a map *F* of a set $E(V^2)$ is a graph. The elements of the set *V* are called vertices, the elements of set *E* – graph edges, and *F* the mapping of the incidence graph.

DEFINITIONS OF A WORKFLOW MODEL BASED ON A GRAPH

To represent the document flow graph of technical documentation the following format is accepted

$$G = (V, E, R),$$

where *V* – set of graph vertices, *E* – the set of edges of a graph, *R* – the set of relations of incidence.

Thus, a graph G consists of a non-empty set of elements called vertices; a set of connected pairs from a set of vertices called edges; and a set of edge direction features [3].

A set consisting of vertices of a graph G is called the set of vertices of a graph and is denoted by *V(G)*. Similarly, a set consisting of edges is called the set of edges and is denoted by *E(G)*. If v_i and v_j are vertices of the graph G, then the edge of v_iv_j is called the connection that connects v_i and v_j.

Two vertices v_i and v_j are boundary vertices of an edge *e* if v_i is the beginning of the edge and v_j is the end of the edge. Two vertices v_i and v_j are adjacent if they are distinct and exist, and there is an edge running from one of them to the other. It is assumed that an edge *e* comes from vertex v_i if v_i is the beginning but not the end of *e*, and that an edge goes to v_i if v_i is the end but not the beginning of *e*. In both cases,

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the edge *e* is called the incident vertex v_i, and the vertex v_i is called the incident edge *e*. The total number of edges incident to vertex v_i is a power of vertex v_i and is denoted $b(v_i)$.

THE MATRIX FORM OF PRESENTATION OF THE DOCUMENT MANAGEMENT OF TECHNICAL DOCUMENTATION

To represent the workflow of technical documentation, it is advisable to use the matrix form. The matrix form uses three sets from the previously introduced triple {*Y, P, F*}.

It is believed that at the time of submission occurred updating the sets, i.e. all the States are represented by many forms, all actions leading to state changes lots of action, and the manufacturing steps in the form of roles in many of the participants. A matrix model is a model of the current state of the technical documentation workflow that operates with a finite number of technical documents.

To solve the above problem, it is proposed to use a set of flat rectangular document flow matrices, each of which represents the state of the system in a discrete unit of time. Columns in the workflow matrix are set to match the document States that are possible within the workflow lifecycle.

That is, the first column corresponds to the first element of set *F*, the second column the second element and so on, until the last element of the set *F*. The matrix Rows of the document are associated with the process, the product of which leads to a change of state of at least one document. The first row corresponds to the first element of the set *P*, the second row to the second, and so on, for the entire set *P*.

Thus, it is got a rectangular matrix with columns, the number of which is equal to the dimension of the set *F* and rows in the dimension of the matrix *P*. this matrix is Filled with elements of the set of role participants in the modeled document flow *Y*. An element is filled into a matrix cell if and only if the corresponding participant performs an action corresponding to a row element, which results in a change in the state corresponding to the column element.

If the row action does not change the column state at this workflow step, the matrix element is filled with empty or null values. The criterion for the success of creating a matrix is its non-degeneracy in columns and rows. In other words, there is at least one column in the matrix that contains a non-empty element, and at least one row that contains a non-empty element. However, it is assumed that not all elements of the set of role participants in *Y* will be used for filling in.

Thus, a matrix of technical documentation workflow is obtained, the content of which uniquely corresponds to the state of document flow at the first step. After the first event occurs, namely, after the first action occurred that led to a change in at least one state, will be updated the workflow matrix. Namely, the matrix content will be brought in such a way that the matrix elements correspond to the current state – the second step of document flow. Thus, at the second step, get a matrix filled in by the participants of this step, who are at the intersection of the actions they perform and the States that these actions change.

Since the number of workflow steps may be large, but it is still finite, the workflow itself can be represented as a finite set of matrices

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described above. Each matrix represents the overall state of the entire composite document management system at a time when there is no change in document States.

GRAPH-BASED WORKFLOW MODEL

To illustrate the meaningful meaning of the concepts used, will be considered a document flow model based on the proposed graph model.

As a basis, will be considered the General technological process of maintaining custom specifications (MCS) for railway automation and telemechanics (Fig. 1), presented in the article [4].

The process consists of the following steps:

1) The Project organization makes custom specifications (CS) based on the completed project for the objects under construction or reconstruction.
2) The compiled CS is approved by the automation and telemechanics service.
3) After that, the CS is sent to the capital construction Department (CCD). This data is used to determine which equipment manufacturers need to order. Since there are several hundred items of equipment and devices in the CS, the probability that only one factory produces them is very small. CCD divides the equipment specified in the CS between suppliers.
4) Suppliers, in turn, give an order to the factory to complete the order.
5) At the end of the work, the plant sends the equipment to the warehouse signaling distance.

Will be considered the General technological process of technical characteristics CS of railway automation and telemechanics (Fig. 1), given in [5-7].

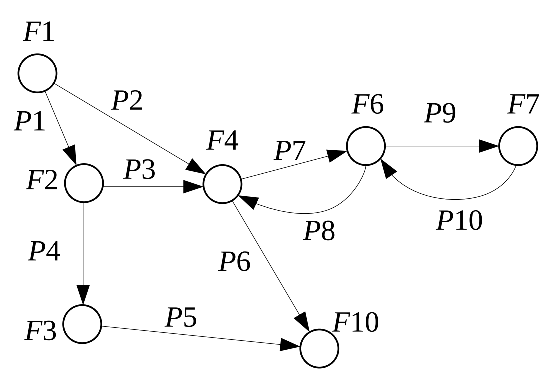

Fig. 1. Graph of the technological process for maintaining specifications of railway automation and telemechanics

The following notation is used to set model parameters:

- Documents are indicated by a set of forms used in the modeled process. Note these forms F1...F10.
- The process performed by documents that change States is defined by a set of processes P1...P10.
- Performing processes P1...P10, are denoted by the set Y1...Y10.

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Possible scenarios for the process of maintaining custom specifications that can be implemented by a given model will be considered. For this a table in the form of a matrix (table 1) and possible transitions of the VSS process will be made (table 2).

From table.3.1 defining the set Y:

$Y1=P2F4 \vee P1F2$
$Y2=P1F2 \vee P3F4 \vee P4F3$
$Y3=P4F3 \vee P5F10$
$Y4=P2F4 \vee P6F6 \vee P9F4 \vee P3F4 \vee P4F10$
$Y6=P6F6 \vee P9F4 \vee P7F7 \vee P8F6$
$Y7= P7F7 \vee P8F6$
$Y10=P5F10 \vee P4F10$

TABLE I. MATRIX TABLE {Y, P, F} FOR THE MCS PROCESS

F \ P	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
P1	Y1	Y1 Y2								
P2				Y1 Y4						
P3				Y2 Y4						
P4			Y2 Y3							
P5										Y3 Y10
P6						Y4 Y6				
P7							Y6 Y7			
P8						Y7 Y6				
P9				Y6						

				Y4						
P10										Y4 Y10

TABLE I. TABLE OF POSSIBLE TRANSITIONS OF THE MCS PROCESS

#	P	F	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
1	P2	F4	1			1						
2	F6	F6				1		1				
3	P9	F4				1		1				
4	P7	F7						1	1			
5	P8	F6						1	1			
6	P1	F2	1	1								
7	P3	F4		1		1						
8	P4	F3		1	1							
9	P5	F10			1							1
10	P4	F10				1						1

From the set Y, those that have the same elements are combined:

Y6= P6F6$^{\vee}$P9F4$^{\vee}$Y7

Will be applied graph theory terminology to the workflow model of technical documentation. Then the possible workflow scenarios correspond to the graphical paths (Fig. 2).

In the presented graph, there are five possible paths, which are denoted by edges.

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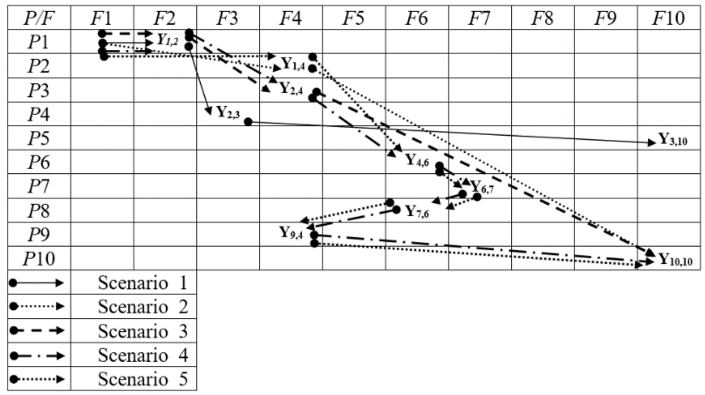

Fig. 1. **Graph transitions of the technological process of maintaining specifications of railway automation and telemechanics**

These paths correspond to the scenarios MCS.

Will be imagined the EDTD matrices corresponding to the considered scenarios. At each stage of the script, a workflow step is performed that corresponds to the work being done on the documents.

Scenario 1. at stage 1, the elements of the matrix P1, F1 and P1, F2 get the values Y1 and Y2 (Fig. 2). At stage 2, the matrix elements P1, F2 and P4, F3 get the values Y2 and Y3, and at stage 3, the elements P4, F3 and P5, F10 respectively get the values Y3 and Y10.

Scenario 2. At stage 1, the matrix elements P1, F1 and P2, F4 get the values Y1 and Y4, respectively. At stage 2, the matrix elements P2, F4 and P10, F10, respectively, get the values Y4 and Y10.

Scenario 3. at stage 1, the matrix elements P1, F1 and P1, F2 get the values Y1 and Y2. At stage 2, the matrix elements P1, F2 and P3, F4 get the values Y2 and Y4, and at stage 3, the elements P3, F4 and P10, F10 respectively get the values Y4 and Y10.

Scenario 4. at stage 1, the matrix elements P1, F1 and P1, F2 get the values Y1 and Y2. In step 2, the matrix elements P1, F2 and P3, F4 to get the values Y2 and Y4, for phase 3 elements P3, F4 and P6, F6 respectively receive the values of Y4 and Y6, in step 4, the elements P6, F6 and P7, F7 respectively receive the values of Y6 and Y7, in step 5 the elements P7, F6 and P8, F6 respectively receive the values of Y7 and Y6, and in step 6 the elements of P8, F6 and P9, F4 respectively receive the values of Y6 and Y4, in step 7, the elements P9,F4 and P10,F10 respectively receive the values of Y4 and Y10.

Scenario 5. At stage 1, the matrix elements P1, F1 and P2, F4 get the values Y1 and Y4, respectively. In step 2, the elements of the matrix P2,F4 and P6,F6 respectively receive the values of Y4 and Y6, stage 3 elements Y6, Y7 and P6, F6 respectively receive the values of Y6 and Y7, the stage 4 elements P7, F7 and P8, F6 respectively receive the values of Y7 and Y6, in step 5 the elements of P8,F6 and P9, F4 respectively receive the values of Y6 and Y4, in step 6 the elements of P9,F4 and P10,F10 respectively receive the values of Y4 and Y10.

Based on the methodology for constructing a conceptual model of document flow systems for technical documentation and a composite document flow model, this article presents a graph model of electronic document flow for technical documentation, which takes into account the decomposition of document flows into a set of process participants, a set of States, and a set of actions.

Obtained result:

- Survey of real processes of creation, verification and use of technical documentation of automation and telemechanics systems;
- Document flow scenarios and protocols of technical document properties are identified;
- Developed a method for creating a model of electronic document flow of technical documentation based on the graph theory apparatus;
- It is proposed to use a set of flat straight-angle matrices to set the matrix form for the representation of technical documentation workflow;
- Methods for defining sets for the proposed model are described, and an algebra of technical documentation workflow with the use of graphs is proposed.

PROSPECTS

- Further improvement of the theoretical base of technical documentation workflow
- The ability to effectively identify all possible scenarios of document movement in the process, describe all possible document States, and identify possible participants
- Development of computer application software based on the graph theory apparatus for solving problems of document management of technical documentation of railway automation and telemechanics systems.

Electronic document management on the basis of full functional support and development of the electronic-executive part of the system for monitoring and recording railway automation and telemechanics devices in the form of automated control systems allows the management and distance of signaling and communication, as well as enterprises involved in the processing of technical documentation to be significantly increased.

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