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Research Article
Algorithm for Structural and Parametric Synthesis of Electronic Document Management System of Research and Education Institution

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Abstract

Background: This study presents an algorithm of structural and parametric synthesis of Electronic Document Management System (EDMS) of research and education institution. **Materials and Methods:** The functional diagrams in IDEF0 notation, system analysis methods and the theory of sets and graphs are used in the article. **Results:** The algorithm is based on a modular principle of information system design that enhances its functionality, reduces time and volume of work performed in designing software and enables to use the system in research and education institutions of different size and sectoral affiliation. This algorithm takes into account the influence of new educational and administrative standards and regulations on scientific and educational processes and the structure of the institution, which makes it possible to adjust the EDMS to constantly changing external and internal conditions. As part of the algorithm, the researchers developed a classification of information flow structure to carry out formalization and implementation of document flow processes in the EDMS. **Conclusion:** The result of the study can be applied to further development of document management systems of research and education institutions.

Key words: Electronic document management, classification, system analysis, structural, parametric synthesis

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INTRODUCTION

With the development of information technology, a lot of attention is drawn to automation of industrial processes, research and academic work. In the field of education, the important objectives include transitioning from traditional study work to electronic document management, improving the quality of educational processes and work of academic staff, developing new approaches to safe storage and quick data processing. To solve these problems it is indispensable to create and implement the electronic document management system, taking into account the peculiarities of the subject area[1-3].

Document management systems currently available on the market differ in functionality, scale and orientation. Quite often, such solutions are expensive require serious modernization in adaptation of the system to the organization needs, they lack the needed functionality and do not take into account the specifics of research and education institutions[1,4].

The study describes an algorithm for structural and parametric synthesis of the EDMS of research and education institution, this algorithm is based on a modular principle of construction of information system. This algorithm allows determining the optimal parameters and the structure of the EDMS in order to ensure its maximum economic efficiency.

MATERIALS AND METHODS

It is necessary to analyze the subject area for the solving of a stated task with a help of system analysis methods, to formalize the events on the base of theory of sets and graphs.

It is consider the specifics of electronic document management of research and education institutions. The documents used in academic, research and administrative work can be generated in various information systems, i.e., information is a duplicated in application systems and the EDMS. At the same time, it is necessary to integrate these systems with a general document management system. Moreover, one should consider the following[1-8]:

- Isolation of data for security reasons
- Inability to eliminate study work
- Existence of specific documentation, requiring a special approach to its automation (research projects, results of experiments, individual plans and student reports)

Another problem of designing the EDMS of research and education institution is variability of its document management structure: Under the influence of various external and internal factors (orders instructions of ministries, departments, public authorities and other organizations, new federal education standards, GOST, etc.) the structure of the organization is changed. This brings us to the conclusion that the EDMS must have structural and functional flexibility. This problem can be solved by using structural and parametric synthesis, which makes it possible to optimize not only several parameters of the EDMS but also change the structure of its modules and individual parts, depending on the set conditions[7-10].

To formalize the algorithm of structural and parametric synthesis of the EDMS, it will use the function charts in IDEF0 notation. Firstly, this allows displaying the processes occurring in the domain in detail; secondly, it shows the inputs and outputs, control inputs and mechanisms (tools). In addition, being simple and concise, IDEF0 technology is a standard language used to describe models and processes at different levels of detail.

RESULTS AND DISCUSSION

Algorithm of structural and parametric synthesis of the EDMS is presented in the form of a functional diagram in IDEF0 notation (Fig. 1), which includes the following steps.

A1: Analyzing the organization's information flows: For the first step of the algorithm, the input data is the information on the scope of research and education institution[1,11,12]. First, it was studied the information flows and recorded the data in a non-algorithmic form, using different verbal or graphic tools, such as microsoft visio tools. Then, it was analyzed the organizational structure in order to create a scheme of structural units and a list of tasks and documents to be processed by each department or unit of the organization. In the next step, analyzed the requirements to the structure and the final implementation of the EDMS formulated by the organization governing bodies. Finally, the problem was formulated in the verbal form.

A2: Developing a mathematical model of the EDMS: A mathematical model of the EDMS was developed using the analysis of the existing approaches to modeling of electronic document management and the existing EDMS, methods of system analysis and mathematical modeling. The proposed model accounts for the document management structure, software and hardware parameters of the system, economic costs, productivity and quality of work, domain set of its

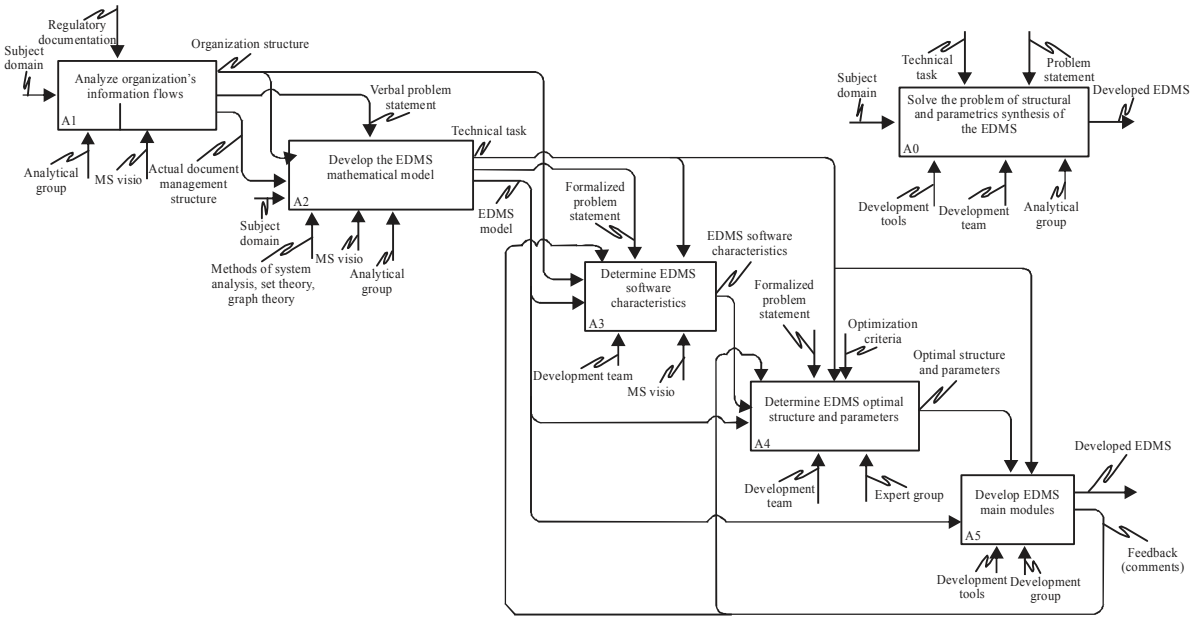


Fig. 1: Functional diagram of the algorithm for structural and parametric synthesis of the EDMS

variables, equations describing the processes occurring in the EDMS[1,5]. Using this model and a graph theory, it was developed a classification of typical structures of information flows, allowing for formalization and implementation of document circulation in the EDMS. Table 1 shows typical structures, their description, mathematical and graphical representations.

The above structures enable to present document circulation processes through the synthesis of simplest structures. Presented in the form of graphs, document circulation processes become formalized and clearly specified. Using the classification of typical structures and information flows and the developed mathematical model, one can formalize document circulation processes in the form of EDMS models as well as formulate a technical task of the information system development and complete a formal statement of the problem of structural and parametric synthesis.

A 3: Determining the EDMS software characteristics: This step involves forming the EDMS structure and specifics of its functioning (performance, reliability, quality, user satisfaction, etc.). The software characteristics, used development tools, modules and structure of the final software implementation play a crucial role. The list of requirements to the information system is formulated on the basis of the technical task and the formalized statement of the problem of structural and parametrical synthesis. Then the development tools are selected and the structure of modules is determined. It is necessary to consider the functions of each module, pluggable code libraries and interface templates. These components fully determine the software characteristics of the developed EDMS. When the system is updated and optimized, the input of the algorithm receives the control action as a set of comments from users or the organization management team. Afterwards the EDMS program characteristics are revised[13].

A 4: Determining the EDMS optimal structure and parameters: At the first iteration of structural and parametric synthesis of the EDMS, the initial approximation parameters are set, then the problem constraints are verified and the criterion value is calculated. If the result is optimum and satisfies all the constraints and requirements of the control action, the parameter values are forwarded to the EDMS for software implementation. If there is variation in parameter values, the previous steps will be repeated until the optimal set of parameters is determined, so as the target function reaches its extreme.

A 5: Developing the EDMS modules: The system modules for academic, research and administrative work are developed on the basis of the EDMS model, optimal values of parameters and structure of the EDMS[13] or this purpose a standard module design scheme shown in Fig. 2 is used.

The algorithm consists of the following steps: Creating database, interface implementation using the selected development tools; implementation of the module functions,

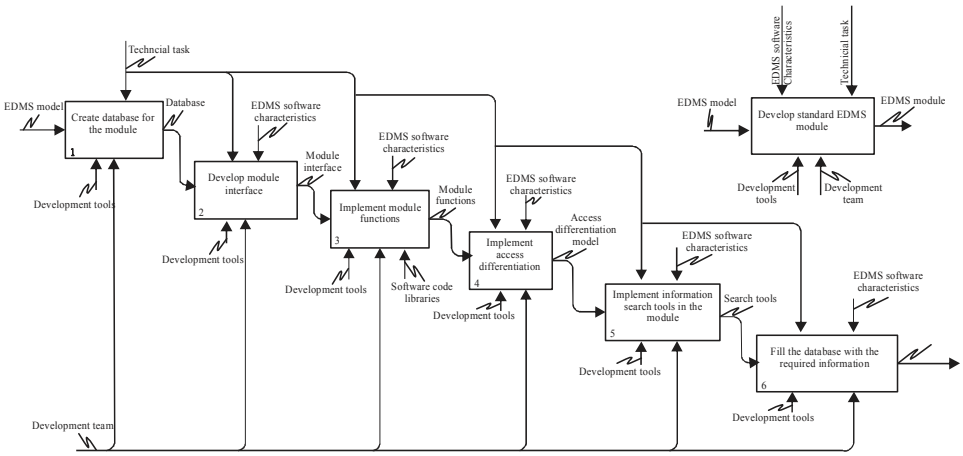
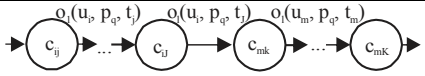
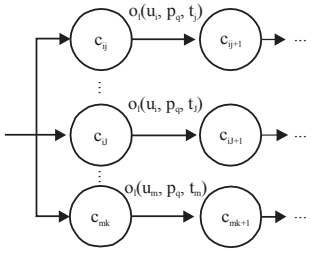
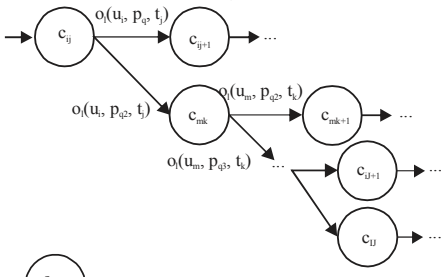
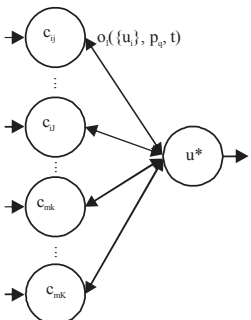
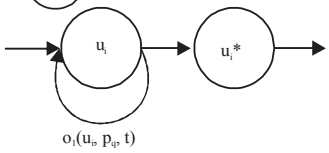


Fig. 2: Diagram of standard module design

Table 1: Main structures of object state graphs

Notation	Mathematical representation	Graphical representation
Linear structure	$c_{ij} \to c_{ij+1} \to \ldots \to c_{mk} \to \ldots$ $\ldots \to c_{mK}, u_i \to \ldots \to u_m,$ $P(o_l, t) = p_q$	
Parallel structure	$c_{ij} \to c_{ij+1} \to \ldots; c_{iJ} \to c_{iJ+1} \to \ldots;$ $c_{mk} \to c_{mk+1} \to \ldots;$ $P(o_l, t) = \{p_q\}$	
Branch	$c_{ij} \to c_{ij+1}, c_{ij} \to c_{mk},$ $c_{ij+1} \to \ldots;$ $c_{mk} \to c_{mk+1}, c_{mk} \to \ldots,$ $c_{mk+1} \to \ldots;$ $P(o_l, t) = \{p_q\}$	
Choice	$C^* \to u^*, C^* = \{c_{ij} \mid i = \overline{1..I}, j = \overline{1..J_i}\},$ $o_l = o_U, P(o_U, t) = p$	
Cycle	$u_i \to u^*,\ u^* \in U^*,$ $O^* = \{o_l(u_i, p_q, t) \mid \text{until } u_i \neq u^*\},$ $P(o_l, t) = p_q$	

including those which require third-party code libraries, ensuring differentiation access using the appropriate model[14], adding data search tools of different degree of complexity, filling directories and auxiliary tables in the database. Following this sequence of steps, a standard module of the EDMS was developed, meeting the requirements to its functionality and software implementation[3,15].

After the completion of the development the modules are debugged and tested; the detected errors, comments or suggestions are sent to the input of block A3 as a control action; then a new iteration of the structural and parametric synthesis of the EDMS begins.

Using the proposed algorithm, we developed information subsystems for the departments of Tambov State Technical University: Department of patent and intellectual property protection, department of basic and applied research and department of training and certification of highly qualified personnel[1,13]. These subsystems were successfully implemented and are used for document automation in the above mentioned departments.

The proposed algorithm of structural and parametric synthesis used in the development of the EDMS reduces the time and volume of work performed through the modular principle of system design and formalization of document management objects, processes of their movement and interactions. Using the algorithmic tools in the form of mathematical model of the EDMS, classification of information flow structures, access differentiation rules, setting the optimization task of hardware and software characteristics of the EDMS, one can simplify the process of formalization of electronic document management, develop and optimize the information system and ensure its competitiveness by enhancing its economic efficiency[16-18].

CONCLUSION

We analysed electronic document management system of research and education institution, identified its specifics and main problems occurring in design and operation of the EDMS within the given subject domain.

Based on modular principle of the EDMS construction, the algorithm of structural and parametric synthesis in IDEF0 notation enables to reduce the time and volume of the work required to develop software and determine the optimal structure and parameters of the information system. We described in detail the main steps of the algorithm, the tools and approaches used in the EDMS design, formalization and classification of processes of document movement with the help of the developed structures of information flows.

The proposed algorithm of structural and parametric synthesis of the EDMS can be applied to the development of document management systems of research and education institutions and adapted to other subject areas.

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