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Development of Automated Control System for University Research Projects

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Abstract: Electronic document managementis used in designing, manufacturing and sales of industrial products. The need to develop modern automated information systems is caused by a huge amount of documents to be stored and processed. The paper discusses the issues of constructing such complex electronic document management systems in their interaction with the information systemsof company productcatalogs and other types of electronic documents.These systems are developed to solve a number of tasks,such asensuring fast access to information, storage and protection of documents, document flow management, etc. We describe a mathematical model for electronic catalogsin the form of a graph. Based on traveling salesman problem the task of project optimization has been stated. The authors describe the effect of combined application of electronic productcatalogs and document management systems within the company.

Key words: Document circulation · Document flow · Electroniccatalogs · Document management · Automated system

INTRODUCTION

Today, designing, manufacturing and sales of industrial products involve large amounts of documents: project specifications, reports and orders, patents and standards, etc. Safe storage and quick access to these documents contribute tosustainable development of any company. At the same time, the traditional paper-based document management has plenty of shortcomings, hence, there is the need to develop and implement automated information system of electronic document management system (EDMS) [1].

The introduction of such a system is designed to solve the main problems of paper documentmanagement: loss of documents, long search for information, large storage area, low-speed editing, etc.

The purpose of this paper is to study the possibility of integration of electronic document management system and electronic product catalogs.

Storage of documents with no connection to relevant current orders or projects does not make sense as any networked storage can handle such a task. In this respect, the synthesis of EDMS and product catalogs is of the greatest interest. The introduction of electronic document management system can solve a lot of 'hidden' problems and improve the performance of the organization as a whole. First, let usconsider the above mentioned systems separately.

Electronic Document Management System: The main element of the EDMS is a document. Electronic document management system involvesthe arrangement of an electronic archive and the information flow management, as well as automation of various departments of an organization (office, accounting, certification, etc.), possibility to add modules generating contracts, applications, organizational documents (e.g., for meetings, conferences) [2, 3].

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The requirements to modern EDMSsinclude ensuring orderly access to information and improvingcomplex business processes withinan organization [4]. The domestic market systems are slowly developing in this direction, however, they are lagging behind their foreign counterparts, such as Documentum. [5]. In this work, this automated system will be used to consider the main problems solved by EDMS, such as quick access to information, transparency of document flow, implementation of electronic archiving and protection from unauthorized access. In developing the EDMS for research and innovation activities it is necessary to focus on the requirements of the subject area, rather than use expensive software with unnecessary features or free non-optimal solutions.

The practical value of the EDMS implementation is as follows [6-11]:

- Reduction in the time spent on searching and filling out documents.
- Secure storage of documents: all documents are digitized, collected on the server andhave backups.
- Possibility to retrieve accurate information about the authorof the document and all the users to authorize and amend it, with the exact time of the document creation and editing dates.
- Full and partial exclusion of paper documentation from the internal circulationwithin the company and the transition to the electronic version of the archive, resulting in the reduction in the costs of document flow management in the organization [12].

Thus, the electronic document management system streamlines the work of documentation, increase the security of the stored data, but at the same timeit is not be linked to actual production [16-27]. At the beginning of this article we mentioned the possibility of integrating productcatalogs into classical EDMS so as to increase the effect achieved through the automation of document management. This brings us to the need to study product catalogs.

Mathematical Model of Product Catalogs: The majority of documents ofa chemical industry company, for example, are based on product catalogsincluding parts, materials, tools, etc. It is necessary to create such an automated system which will enable the user to edit records, search the database and generate orders by retrieving a group of records from the database and extracting the necessary information (cost, structure, physical and economic characteristics). Given the large number of entries, their strict classification and close links between theproduct itemswe need todevelop a mathematical model at the stage of creating the information system structure and related database of product catalogs [13, 14].

In the first phase of the model development we formed agraph of catalognodes.To illustrate this, we shall consider the structure comprised of the sets of parts, assemblies and products, which together form the final project. At the same time, the assemblies and products are the nodes of the same level and can be incorporated into each other, while the parts are finite elements, forming the basis for the assembly or product.

We Introduce the Following Notation: P is a project document, p_1, p_2... is a set of all products, s_1, s_2... is a set of all assemblies, d_1, d_2... is a set of all parts.

Thus, the project can be shown as a graph $p=[W, M]$, where W- $\{d_1...,d_n,s_1...,s_m,p_1...,p_k\}$ is a set of vertices; M isa set of oriented branches formed in (w_i,w_j) pairs, which are elements of the set W.

Products, parts and assembliescan be incorporated into each other by the following rules:

- Output onlyisparts.
- Input and output arenodes that are often presented by assemblies, but at higher levels they can be represented by products.
- Input only is a project that is the end product.

The edges of the graph are numbered to identify the possible ways of forming the project. As it can be seen from Figure 1, the project can be made with various combinations of vertices (three optionsare indicated). Thus, using the graph, we can assess the projectby various design criteria and if necessary, optimize it using interchangeable components. To ensure the best option, one must find the optimal path [15].

Let $M^{w_i,w_j}=\{w_i,w_j\}$ be the pathbetween the vertices w_i and w_j, with $L(M^{w_i,w_j})$ the length of this path;in order to calculate this length each intermediate branch (w_s, w_t) isassigned a weight factor $l_{ws,wt}$ is applicability of the vertex w_s in the vertex w_t), determining its value: the price of a product, mass of a part, manufacturing time, etc. Thus, the path length from the vertex w_i to the vertex w_j is equal to:

$$L(M^{w_i,w_j}) = \underset{FORALL(w_s,w_t)ISIN(M^{w_i,w_j})}{SUM(l_{w_s,w_t})}$$

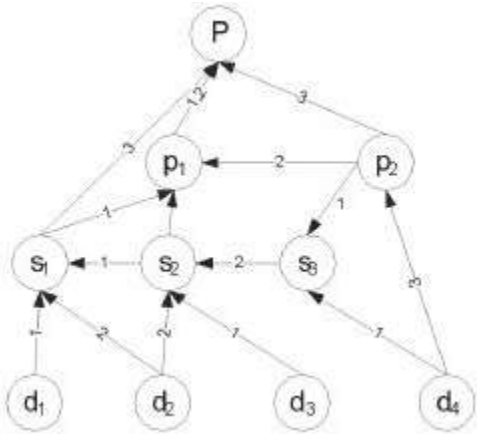

Fig. 1: Presentation of the project in the form of a graph

A full applicability of the node w_i in the node w_j is calculated as a minimum length of the path $M^{wi,wj}$:

$$l_{w_i,w_j} = L_{\min}(M^{w_i,w_j})$$

Consequently, the applicability of the part w_0 in the project is determined as the optimum position of the parts inside the assemblies s_i, products p_j, or in the project P:

$$l_{w_0,P} = L_{\min}(M^{w_0,P}) = \underset{(s_i)ISIN(M^{w_0,P})}{SUM}(L_{\min}(M^{w_0,s_i})) + \underset{(p_j)ISIN(M^{w_0,P})}{SUM}(L_{\min}(M^{w_0,p_j})) + L(M^{w_0,P})$$

Based on the database of products, assemblies, parts and boundary conditions (these are defined by the customer, or the current inventory / business needs and can be expressed in the amount of material / products, cost, company budget enterprise, time slots) we determine the optimal paths in the graph P. Then the goal function is the function of the project efficiency:

$$F(P) = \underset{FORALL(w_i,w_j)ISIN(P)}{SUM}(l_{w_i,P})$$

The formulated problem of the project optimization is formulated as traveling salesman problem,which can be solved by any of the existing methods for extremal combinatorial problems, such as the exhaustive method,the branch-and-bound method. As a result of solving the problem, the optimal set of parts, assemblies and products for the given order is formed [15].

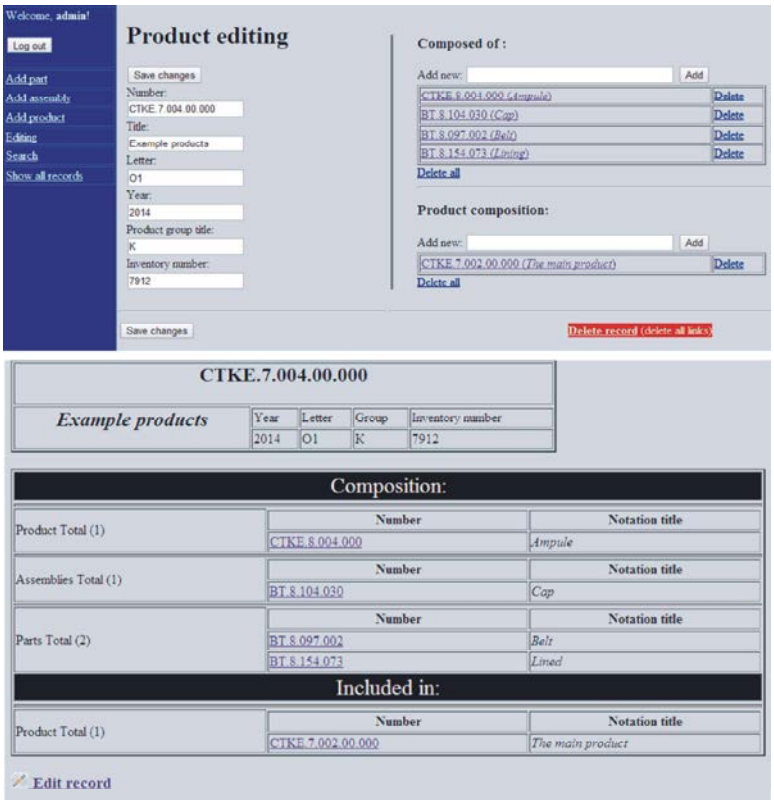

Fig. 2: The interface of the product catalog module.

Software for Product Catalogs: The scripting language PHP and the web server Wampserver (includes Apache, MySQL, script interpreter PHP, phpMyAdmin) were used as tools for developing a prototype module of productcatalogs [16, 17, 22-27]. The design was implemented in accordance with the principles of object-oriented programming, as well as the concept of MVC template:

Model: The main executable code is packed in a separate class responsible for data checking, database use and generating some basic elements of data output.

Controller: Data management, its output to pages as well as information retrieval from the forms is handled on separate pages by appropriate Model class. Thus, each page performs its tasks in terms of the basic classes of Model.

Representation: The external interface (implemented by Cascading Style Sheets-CSS) is determined separately and applied to all pages of the site.

The authorization allows users to edit, add and delete records. Unauthorized users can only view records. Figure 2 shows the interface of the developed prototype for the product catalog module.

The developed software is a prototype and suggests further development by adding digital signature functions, intelligent search and creation of a mobile version of the project.

CONCLUSION

The analysis of the document management system and automated product catalogsbrings us to the conclusion that the product catalogscan be optimally integrated into a comprehensive electronic document management system as an external module. Furthermore, this integration can improve the efficiency of the system due to the possibility of storing any lists of parts or products and referring to specific documents, drawings, reports, patents and other documents.

Authorized users of the combined system have access to both the product database and all accompanying documents (instructions, technical specifications, certificates, etc.).

Obviously, the combined document management systems can be used forstoring and processing of documents in the systems linked to real production and business processes of an organization. The EDMSsof this type ensure the safety and reliability of informationand enable to affect directly the efficiency of production as a whole.

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