

Logic-Mathematical Apparatus of Data Processing Used in Information Technology of Web-Portal Development

Svitlana Bevz

Vinnitsia National Technical University, Vinnitsia, Ukraine
svbevz@rambler.ru

Abstract. The paper suggests the improved logic mathematical apparatus, used for development of computer systems, the given apparatus enables to unify the description of information models and determine the existing links between databases tables. Models, serving as the base for information technology of automated web-portal design, have been developed, using the given apparatus. The creation of the structure and algorithm of information technology for automated data processing has been performed.

Keywords: information models; logic-mathematical apparatus; information technology; web-portal.

1. Introduction

Today automated data processing is one of the most important tasks in information technology (IT) industry. There exists quite a good number of IT for solution of the problems, dealing with the data processing in information systems (IS) [1-3]. However, data management in IS with geographically-distributed structure is quite time-consuming task and requires a specialized approach to provide the integration of information space of complex hierarchical computer system subjects.

For monitoring, managing, processing and analysis of IS data various models, methods and modeling tools are used [4-8]. Wide functionality and classification of separately taken methodologies, however, does not allow to solve the complex of problems of data consolidation on the Web portal, in particular, formation of hierarchical structures, created using specific methods, for example containing recursion for monitoring of catalogs and elements or groups and subgroups of users.

To unify and extend the functionality of the existing methods in [9], the author of this article offered a logical mathematical apparatus for data processing, which enables to automate the process of information systems design by means of models transformation in the user interface of Web portal. The task of the development of IT for processing of data of Web Portal hierarchy structure requires extending of functionality area and application of prior developed logic-mathematical apparatus.

Taking into account current trends of web-based information technologies development [10, 11], for testing and promotion of research results of Masters, Postgraduates,

applicants for the scientific degrees and young scientists the Institute of Graduate, Post-graduate and Doctoral Studies (InGPDS) of Vinnytsia National Technical University (VNTU) developed a young scientists web-portal as an interactive environment, oriented to the filling of online resources of virtual scientific-educational space.

Solution of urgent problem of information technology development, intended for processing of young scientists portal data, requires the usage of logic-mathematical models for automation and unification of data management methodology.

The aim of research is to increase operation efficiency of information system used for monitoring, data analysis and processing. The object of the research is information technology of automated processing data at young scientists portal. The subject of research are logic-mathematical models of web portal data processing.

To achieve this aim the following problems should be solved:

- improvement of the logic -mathematical apparatus of data processing;
- construction of information model of web portal data set ;
- development of logic-mathematical models for analysis and processing of the portal elements data;
- development of the information technology architecture for web portal data processing;
- development and introduction of information technology software in higher establishments.

2. Logic-mathematical apparatus of automated data processing

In the process of web portal operation its information content is constantly updated and refreshed by the user, new problems arise, they often require non-trivial approaches to their solution, for instance, change of data structure in the process of system operating, change of user interface, change of design patterns. In order to consolidate the information and data processing and for the solution of the above-mentioned problems, the usage and further development of logic-mathematical apparatus developed in [9] is suggested.

Table 1 presents twelve information models for the automation of data processing, with the description of their components.

Table 1. Information models of data processing, designation of operations and symbols

№ пп	Model	Designation	Description
1	$D = A [A_1, \dots, A_n]$	$A_k \in A, k = \overline{1, n}$ – attributes of table A	Projection of table A
2	$D = A(h(A))$	$h(A)$ – logic condition using attributes of table A	Sample of table A
3	$D = A \langle q(A, B) \rangle B$	$q(A, B)$ – logic condition of tables A and B consolidation	Rigid union of tables A and B
4	$D = A \langle \langle q(A, B) \rangle \rangle B$	$\langle \langle q(A, B) \rangle \rangle$ – logic condition of tables A and B external consolidation	External unification of tables A and B (each record of table B is united with the record set of relation A).
5	$D = A \left[\begin{array}{l} A_1, \dots, A_n, \\ f(G_1), \dots, f(G_m) \end{array} \right]$	$f(G_i)$ – function of aggregate attributes usage	The use of aggregate functions (<i>avg</i> , <i>sum</i> , <i>count</i> , <i>max</i> , <i>min</i> – functions of mean, total, quantity, maximum and minimum value).
6	$D \parallel P_1, \dots, P_{n_p} \parallel = A(h(A, P))$	$P = \parallel P_1, \dots, P_{n_p} \parallel$ – parameters of the model; $h(A, P)$ – logic condition for A and P	Model of parameters use
7	$D = A [A_1, \dots, A_n]$ $(w(A, \{B'\}));$ $B' = B [f(B_m)](h(B, A))$	B' – model of nested query; $w(A, \{B'\})$ – condition with a nested query	Model of nested query use in the condition
8	$D = A [A_1, \dots, A_n, \{B'\}]$	B' – model of nested query	Model of nested query use in the attributes
9	$D \parallel P_1, \dots, P_{n_p} \parallel = A(h(A, P))$ $\rightarrow Z \{B'\} \rightarrow X;$ $B' = B(h(B, P, Z));$ $R = Z \vee X$	B' – projection of table; $Z \{B'\}$ – internal model; X – result of internal model; $h(B, P, Z)$ – condition of the retrieve from the set B and parameters P	Model of parameters transfer from internal model

10	$D \parallel P_1, \dots, P_{n_p} \parallel =$ $\{B \parallel P'_1, \dots, P'_{n_B} \parallel \rightarrow$ $[B_1, \dots, B_{n_B}]\} [B_{n_{B1}}, \dots, B_{n_{B2}}]$	$P = \parallel P_1, \dots, P_{n_p} \parallel - \text{set}$ of parameters; $B = [B_1, \dots, B_{n_B}] -$ $\text{the result of the nested}$ model	Model of parameters use in nested query
11	$D = A[H_1(A_1), \dots, H_m(A_m),$ $f(A_{m+1}), \dots, f(A_n)];$ $H_k(A_k) =$ $\begin{cases} S_0(A_k) = A_k, A_k \notin SA; \\ S_m(A_k) \neq H_j(A_k); \\ A_k \in SA; \\ j \neq k; m = 1, n_s - 1; \end{cases}$ $A_k \neq G_m, A_k \in A, k = 1, m;$ $G_r \in A, SA \subset A, r = m + 1, n$	$S_j(A_i), j = 1, n_s -$ $\text{function of ordinal sorting}$ of attributes; $S_0(A_i) = A_i - \text{function}$ $\text{of attributes usage}$ without sorting	Model of data sorting and grouping
12	$D = \text{rec}(C(h(C))\langle g(C, B) \rangle$ $\{B \rightarrow \parallel B_1, \dots, B_k \parallel \} [sum(B_k)])$	$h(C) - \text{initial recursion}$ condition, $g(C, B) - \text{condition}$ $\text{of subsequent element}$ of recursion, $B - \text{the internal query}$ of recursion; $[sum(B_k)] - \text{summa-}$ $\text{tion of recursive que-}$ $\text{ries results by attribute}$ B_k	Model of recursion

Model of parameters usage in the nested request and recursion model, used in computer system for automatic processing of hierarchical data structures, traditionally found IS of web-portals are added to ten models, developed before [9].

Therefore, logic-mathematical apparatus has been improved and supplemented by two new models. The construction of information models of automated data processing of the computer systems in particular – young scientists web-portal is realized using the suggested logical-mathematical apparatus.

3. Informational model of data set

The basis of young scientists web-portal, as in any automated web-based system is a database. Software orientation of web portal, which is integrated in the unified automated information system of document management and monitoring of educational process of Masters' training [3], provides information and analytical possibilities of modern web-based system with distributed structure and uses the database of the existing system.

Data bank structure of young scientists' portal in rather simplified form is shown in Fig.1. It contains four main units: users, directories and elements, models and relationships, characteristics of the interface. Module of models and relationships plays a key role in managing portal objects and subjects.

The diagram contains designations of tables and their attributes. They will be used for construction of logic-mathematical models for portal data processing.

4. Logic-mathematical models of information technology

Let us consider practical application of logical-mathematical apparatus, models of which are presented in Table 1. We will construct information models of data management and processing for young scientists portal.

Portal authorization is performed during user identification by means of login Xlo and password Xps using model of projection and retrieval:

$$Xid = U[Uid] ((Ulo = Xlo) \wedge (Ups = Xps)). \quad (1)$$

In case of a successful identification ($Xid > 0$) information system (IS) determines the user code Xid . Guest login ($Xid = 0$) restricts the rights of portal users.

Users belonging to the administrators group ($Gid = 4$) is represented by the model using aggregate function to calculate the number of tuples:

$$Xadm = G <Gid=Agr>A [count(Gid)] ((Gid = 4) \wedge (Aus=Xid)), \quad (2)$$

which determines the parameter of the system $Xadm$, computing the amount of set A records of target groups and portal user code portal. Similarly user identification of belonging to other groups of the portal members is performed.

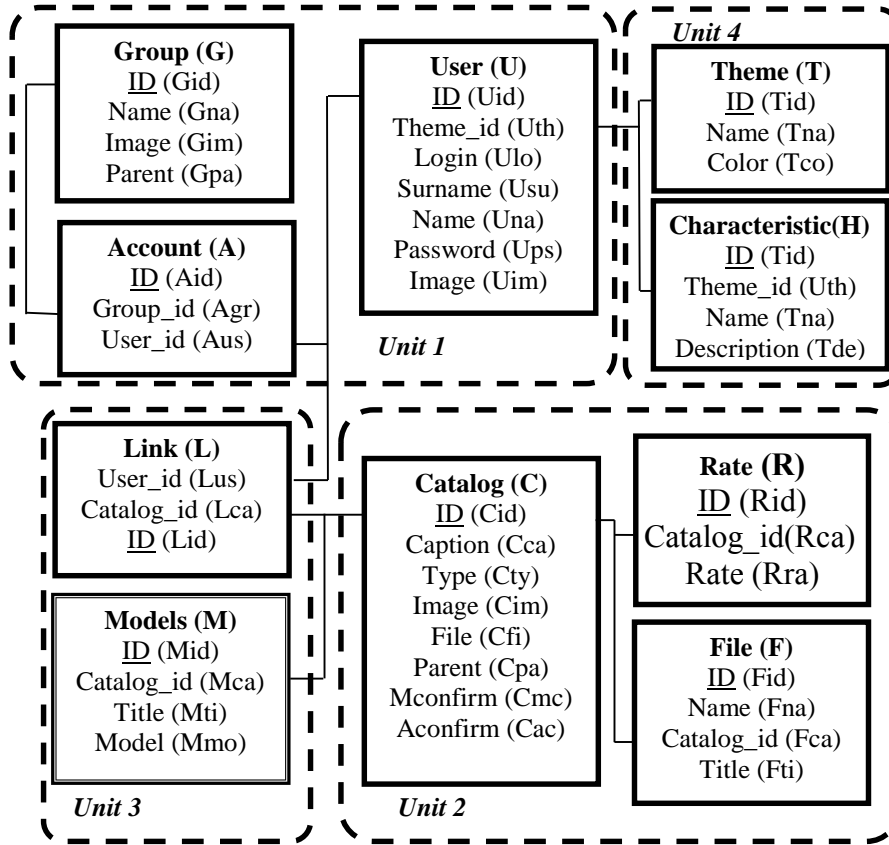


Fig. 1. Databank of young scientists' portal

Since each element and the catalogs, descriptions of which are stored in the set C , may refer simultaneously to several users of the portal, then we write the model of all elements and catalogs of the portal E , which is formed by the union of the sets of catalogs and elements C and interlinks with users L by means of the model of rigid combination:

$$E = C < (Cid=Lca) > L. \quad (3)$$

Provisional table of catalogs and their elements is formed on request of guest viewing of Vg , confirmed by data administrator using sample model combination:

$$Vg=C (Cac =1). \quad (4)$$

Revision of user's information portal Vu displays personal elements and catalogs, published by him on a Web page, as well as data objects, confirmed by administrator, as the union of data sample models:

$$Vu = E((Eus=Xid) \wedge (Eac=0)) \vee C(Cac = 1). \quad (5)$$

Administrators display all the elements and catalogs Va , which are confirmed by the participant of the portal – author of information objects, according to the sample model:

$$Va = C(Cmc = 1). \quad (6)$$

Information regarding catalogs and elements of the portal is expedient to store in one relation table of database. Tuples of their data differ by attribute Cty , which equals 1 for the catalogs, and for elements – 2. Number of subsidiary elements Vk for display of k^{th} catalog:

$$Vk = rec (((Cty = 1) \wedge (Cid = k)) \langle Cid=Rpa \rangle \\ \{C[Cpa, count(withid)] \rightarrow |Rpa, Rcnt || \} [sum(Rcnt)]). \quad (7)$$

Recursion is used in (7), which complements the logic-mathematical apparatus (see Model 11 of table 1), using the parameters Rpa , $Rcnt$ – code of the parent element and the amount of its subsidiary elements, respectively.

Review of m^{th} element of catalog m displays file Vm and a list of hyperlinks Vn in accordance with the following data sample models:

$$Vm = C[Cfi] (Cid=m); \quad Vn = F[Fna, Fti] (Fca=m). \quad (8)$$

Some catalogs of the portal are characterized by rating of users scientific achievements. Total rating takes into account all the achievements of s^{th} participant of Vs portal, presented in his catalogs and elements and is determined by the model of data retrieval and aggregate:

$$Vs = R \langle (Eca = Rca) \wedge (Eus = s) \rangle E[sum (Rra)]. \quad (9)$$

Formulas (1)-(9), developed on the common methodological base are information models of logical-mathematical apparatus for web-portal data processing in accordance with the above-mentioned structure (see Fig. 1).

We will carry out the construction of information technology of information processing, relying on the above-mentioned models.

5. Information technology of data processing

Based on the suggested logical-mathematical models, methods of processing data that realize the function of automated design of SQL requests of information portal are developed, this enables to change rapidly the structure of the data and parameters of the computer system in the process of its operation and provides the necessary degree of integrity of information database, and also improves the efficiency of data processing of the portal due to reduction of time for data consolidation and formation of users' queries.

IT of young scientists' portal construction is based on the developed models and methods of data processing.

Let us consider the architecture of information technology and basic principles of its functioning. Fig. 2 shows the architecture of the information technology for automated processing of portal data.

Management of information system interface is carried out design patterns of user interfaces that on the base of style sheet and description of Web pages structural blocks realize combination of the data model processing results and user interface elements, which, in its turn, allows to process efficiently data sets using standardized software functions.

Information technology is implemented in accordance with modular principles of libraries shown in Fig. 2, which provide wide functional possibilities of the portal. Module of models formation provides information support of the process of the development of logical-mathematical models for functional support of the system, processing and data analysis and creating account forms. To save objects, interface parameters, and interlinks with subjects database server MySQL is used.

Created information technology architecture, unlike the existing technologies allows:

- use one and the same element both for publication on a personal website that is automatically generated for the portal user and in the tree of its catalogs accessible to Internet community, or to the community of researchers, scientific schools;
- perceive one and the same user as a participant of various groups at a fixed moment of time and at various moments of time, taking into retrospective of catalogs and their content;
- use one and the same element of the portal, taking into consideration time retrospective for several authors, enabling to save the resources of the disc space and time of data processing;
- perform data analysis and computation of scientific rankings both for separately taken portal user and for groups of users, for example, scientific school department, institute.

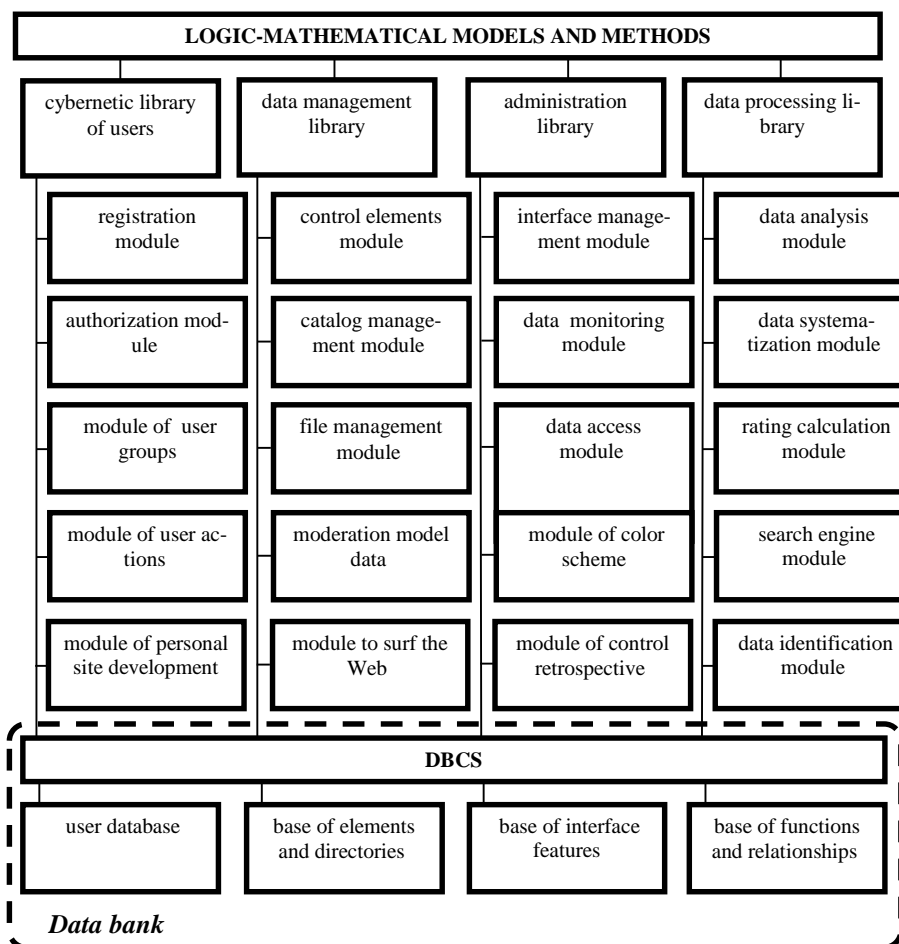


Fig. 2. Information technology architecture

Using the suggested methods of automated processing and data analysis algorithm of information technology that performs the formation of information space for young scientists portal and provides its functionality has been developed: analysis and data processing, elements and catalogs control, user groups management, administration, creation of personal users websites by data publishing and editing directly in the system of formation and browsing the web document, loading of text and graphic information, web-surfing of multimedia files, posted on public servers.

On the base of algorithm of portal functioning software modules for information technology realization are developed. These modules perform monitoring and analysis

of information and enable to improve the effectiveness of automated data processing in information system.

6. Practical implementation of data processing information technology

Efficiency and performance of the developed models, algorithms and methods of information technology for data processing is proved by their program implementation and application at Vinnytsia National Technical University. Young scientists portal for (<http://inmad.vntu.edu.ua/portal/>) in 2014 started its work and today registration of new users, catalog creation and filling them with information resources is performed. The portal interface is illustrated in Fig. 4.

The code of the portal is written in PHP language using MySQL database server and Apache web server. Design and test version of the portal were developed in 2013 in the environment Visual Studio Ultimate 2012 using the database server SQL Server 2012 Enterprise Edition [12].

Further use of the suggested information technology for automated data processing and accumulation of information resources for web-portal will allow to perform calculation of the scientific schools and individual scientists trajectory of development to determine the optimal vector for accumulation of scientific knowledge with the criterion of optimality in various scientific practical fields.

Today the scientific community of Ukraine is open for communication with scientists and researchers in other countries and realizes joint projects, development and implementation of innovative technologies, in particular, in the field of education. Information, regarding new research achievements is of great importance for training of highly qualified scientific staff. Presentation of the research results on the portal pages increases the motivation of young scientists, enhancing the efficiency of their scientific research.

7. Conclusions

Logic-mathematical apparatus of models of automated data processing representation was further developed in the given research. By means of this apparatus it becomes possible in a simple and understandable form describe the parameters of data analysis, processing, aggregation, and take into account existing relationships between tables of relational database. Models of parameters usage in the nested request and recursion are added to logic-mathematical apparatus, thereby expanding the scope of this apparatus and automate management and data processing functions of hierarchical structures. By

means of the suggested logic-mathematical apparatus the construction of application fields information models – portal is realized on the common methodological base.

By means of a computer system based on information models of data processing automated generation of necessary SQL requests and construction of information tables using template design of the page is carried out, that enables to improve the efficiency of web-portal data processing.

New technology of information processing is developed. It differs from existing systems by logic-mathematical models of data formation and allows to consolidate and arrange portal elements, taking into account the data structure of the given information system and allows to enhance the efficiency of resource management.

Practical implementation of developed information technology of data processing automation in the program resource – young scientists portal, has been illustrated, on the example of the portal put into operation at Vinnytsia National Technical University.

In future we plan to continue the research of functional possibilities of logical-mathematical apparatus in the sphere of data analysis and management of their processing, and also extend the sphere of logic-mathematical models application on other areas for information technology implementation.

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Логико-математический аппарат обработки данных для использования в информационных технологиях при разработке Web-порталов

Свитлана Бевз

Винницкий национальный технический университет, Винница, Украина
svbevz@rambler.ru

Аннотация. В статье предложен развитый логико-математический аппарат, используемый при разработке информационных систем. Предложенный аппарат позволяет унифицировать описание информационных моделей и определить существующие связи между таблицами базы данных. Модели в основе информационной технологии, используемой при автоматическом построении Web-портала, построены при помощи предложенного аппарата. Создана структура и алгоритм технологии для автоматической обработки данных.

Ключевые слова: информационные модели; логико-математический аппарат; информационные технологии; Web-портал.