Building Automation of the Computer Systems of Management Reporting

Alexander N. Romanyuk, Svitlana V. Bevz, Sergii M. Burbelo

Abstract—The codification system of models has been suggested in the article, which unlike the others makes it possible to unify the description of the basic information models. The use of the proposed logical-mathematical apparatus of representation models was illustrated by way of example of developing an automated system for building computer control systems of management reporting. The formation of the control system of power sales reporting of "Vinnytsiaoblenergo" Ltd. was made by the use of the developed information technology.

Index Terms—**automation, design of computer systems, information models, optimal control**

I. Introduction

Design of computer geographically distributed systems of data processing in general is time-consuming process. Therefore it requires further automation that consists in identifying key processes by using a specific template, which has embedded means of scaling and directed at system functioning on the basis of the single-valuedness performance of determining of practical use limits.

Currently, the problem of automated development of information-analytical systems for monitoring parameters, identification, consolidation, structuring and processing of information data flows is not solved in full. At the same time the need to use such computer systems is constantly increasing. Nevertheless, some practical problems connected with report data acquisition, report data vetting and analysis of report information are successfully solved by automated information systems [1-2], but these automated information systems do not permit to solve effectively problems of control and consolidation parameters of complex hierarchical systems as well.

The actual problem-solving of development of logical-mathematical apparatus and algorithm approaches for creating on its basis of the information technology of computer-aided formation of the computer system processing of reporting, which would make it possible to overcome previously mentioned deficiencies in the design of such systems, requires the integration of information space of the central and organization departments of the enterprise.

The study of information flows of computer system should be performed by constructing structural and logical-mathematical models for the formation of the information infrastructure of computer systems and databases. The development of computer systems using a relational database often requires the creation of SQL-scripts [3], in this case, XSLT-transformation are used. The methods and principles of creation of information models in automated control systems for identifying factors that affect the teamwork of the human operator and automated control systems are considered in [4], the perceptual of information models is analyzed.

The models [5], which do not permit to characterize the connection sets in the tuple data and have a complicated description of the attribute sorting and result grouping of the aggregate function [6], are known structural descriptions of the basic operations of the data retrieval using SQL (projection, selection and integration) in relational databases. Thus, the currently existing logical-mathematical apparatus of the representation of models of the automated formation of computer systems requires some improvement for taking into account the features of computer modeling and its description in the sign models of the program code generation.

II. Goals and Problem Statement

Report processing should be performed in a generalized informational and analytical automated system developed by information technology using the standardized methodology of monitoring, identifying, structuring and analysis of the information data flow on the basis of the comprehensive approach of its consolidation.

The goal is the improvement of the informational and analytical system operation efficiency at the expense of the optimization of information data flows during the consolidation of reporting of some departments by the use of the technology of the automated formation of information processing systems.

The organization of information exchange between departments and the company's management requires the development of informational and analytical system, where **the object of the research** is the information technology of the automated formation of computer system in the form of a two-level hierarchical structure, namely: the subsystem of

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978-1-4577-1070-4/11/$26.00 ©2011 IEEE

preparation and processing reporting by employees of some departments of the company; subsystem monitoring and analysis of reporting by the employees of company's central control.

The subject of research is the methodology of the automated process of the consolidation of synthesis, analysis, control, reporting and identification of technical and economic indicators as well.

To achieve the goal the following **problems** are solving in this work: the the creation of logical and mathematical software for simulation of the automated formation of the computer systems of management reporting, the development of the methodology of the automated formation of informational and analytical system that uses a synthesis of reporting templates, modules of the completion of consolidated data forms, forms of cross-validation, database structure and system interface, development of the software of the automated formation of the computer system of management reporting.

III. The Development of the System Codification of Information Model Structure

A new codification system of the structure of information models, which are denoted by $D^{<n_1,\ n_2>}$ (n_1, n_2 – number and type of model) is proposed to simplify the recording of information models and display in full the hierarchical structure of the queries and the relationships between them.

The unary operation of projection is represented in the form of writing characterized by display of the attributes in square brackets directly after the relation:

$$D^{<1>} = A\ [D_1,\ \ldots,\ D_{n_D}],$$

$$D_k \in A,\ k = \overline{1,\ n_D},\ n_D \le n_A,$$

where n_D is a number of the selected attributes of the total number of attribute n_A set A.

The operation of tuple selection is determined by fulfilling the condition presented in parentheses:

$$D^{<2>} = A(g(A)).$$

Strict (internal) union of relations is satisfied when combining

$$q(A,\ B) = (A_i = B_j),\ i \le n_A,\ j \le n_B$$

is denoted by using blunt brackets:

$$D^{<3>} = A\ \langle\ q(A,\ B)\ \rangle\ B.$$

Outer join is described by a model $D^{<4>}$ that is similar to the model $D^{<3>}$ and is defined by the relation $q(A, B)$, but it is possible to denote it in different ways according to the implementation of the selection of tuples from the relations:

$$D^{<41>} = A\ \langle\langle q(A, B)\rangle B,\ D^{<42>} = A\ \langle q(A, B)\rangle\rangle\ B,$$

where $D^{<41>}$ ($D^{<42>}$) is the information model of the choice of all tuples of the relation A (B) and only those tuples of the relation B (A) that satisfy the relation $q(A, B)$.

The use of aggregation functions in the logical-mathematical models can be reasonable in the list of attribute relations using aggregate functions, which can be represented as

$$g(A_i),\ x(A_i),\ n(A_i),\ m(A_i),\ t(A_i)$$

for AVG, MAX, MIN, SUM, COUNT functions of the attribute A_i, $i = \overline{1,\ n_A}$:

$$D^{<5>} = A\ [D_1,\ \ldots,\ D_{n_D}, f(G_1), \ldots, f(G_{n_G})],$$

$$D_k \ne G_m,\ D_k \in A,\ k = \overline{1,\ n_D};$$

$$G_m \in A,\ m = \overline{1,\ n_G},\quad n_D + n_G \le n_A,$$

where $D^{<5>}$ is the information model of attribute aggregation $G_m \in A,\ m = \overline{1,\ n_G}$ grouping attributes $D_k \in A,\ k = \overline{1,\ n_D}$.

There are written the information model of parameter use denoting the incoming and outgoing parameters by sets

$$P = \{P_1,\ P_2,\ \ldots,\ P_{n_p}\},$$

$$R = \{R_1,\ R_2,\ \ldots,\ R_{n_R}\},$$

provide the information model is in direct double parentheses.

$$D^{<6>}\|P_1, \ldots, P_{n_P}\| = A\ [D_1, \ldots, D_{n_D}]$$

$$(g(A, P))\langle q(A, B)\rangle\ B$$

$$[G_1, \ldots, G_{n_G}]\ (g(B, P)) \to \|R_1,\ \ldots,\ R_{n_R}\|;$$

$$D_k \in A,\ k = \overline{1,\ n_D};$$

$$G_m \in B,\ m = \overline{1,\ n_G},\quad n_D \le n_A,$$

$$n_G \le n_B,\ n_R = n_D + n_G.$$

The subqueries in the condition can be represented using curly brackets

$$D^{<7>} = A\ [D_1, \ldots, D_{n_D}]\ (w(A, \{B'\}));$$

$$B' = B\ [\ f(B_m)\ ]\ (g(B, A))$$

$$D_k \in A,\ k = \overline{1,\ n_D};\ f = \overline{1,\ n_A};$$

$$m = \overline{1,\ n_B},\quad n_D \le n_A,$$

where n_B is the attribute number of set B, and aggregation function $f(B_m)$ is identifying by relation $w(A, \{B'\})$ and the relation of the selection of tuples $g(B, A)$.

Model of nested queries in the attributes:

$$D^{<8>} = A\ [D_1, \ldots, D_{n_D}, \{B'\}],$$

$$B' = B\ [\ f(B_m)\ ]\ (g(B, A)),$$

$$D_k \in A,\ k = \overline{1,\ n_D};\quad m = \overline{1,\ n_B},\quad n_D \le n_A,$$

where the subquery is used in the additional attribute of the relation A as the aggregate function $f(B_m)$ of attribute B_m in the condition $g(B, A)$.

The following form of logical-mathematical model can be used to present the results of the external query procedure in the internal query if it is necessary:

$$D^{<9>}\|P_1, \ldots, P_{n_P}\| = A\ [D_1, \ldots, D_{n_D}]\ (g(A, P)) \to$$

$$Z\ \{B'\} \to X;\ B' = B\ [G_1, \ldots, G_{n_G}]\ (g(B, P, Z));$$

$Z = \|Z_1, \ldots, Z_{n_D}\|$; $R = Z \vee X$; $D_k \in A$, $k = \overline{1, n_D}$;

$G_m \in B$, $m = \overline{1, n_G}$; $n_D \le n_A$; $n_G \le n_B$,

where the tuple selection of relation A is made on conditions that $g(A, P)$ are the parameters of internal query relation $g(B, P, Z)$ and combining results in the set R.

There is no doubt that the procedure of separation and grouping of sampling results are significant when building the information model. We suggest displaying it as the order function of attribute sorting, which can be represented as follows:

– $S_j(D_i)$, $j = \overline{1, n_S}$ – for sorting attributes,

– $S_0(D_i) = D_i$ – for attributes without sorting:

$$D^{<10>} = A\ [H_1(D_1), \ \ldots, \ H_{n_D}(D_{n_D}), f(G_1), \ldots, f(G_{n_G})];$$

$$H_k(D_k) = \begin{cases} S_0(D_k) = D_k, \ D_k \notin SA; \\ S_m(D_k) \ne H_j(D_k); \ D_k \in SA; \\ j \ne k; \ m = \overline{1, n_S - 1}; \end{cases}$$

$D_k \ne G_m, D_k \in A$, $k = \overline{1, n_D}$; $G_m \in A$ $SA \subset A$,,

$m = \overline{1, n_G}$, $n_D + n_G \le n_A$,

IV. Building of the Universal System Template of Management Reporting

We consider the system of proposed codification for the construction of logical-mathematical models of management reporting, database structure is given in Fig. 1.

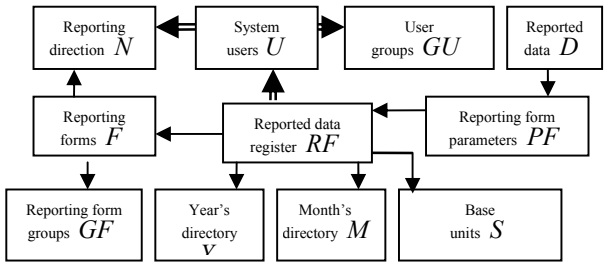

Fig. 1 – The database structure of the universal template of management reporting

The universal method of the retention of data reporting forms is the use of the following major sets of overall structure of the database: – a set of reporting forms

$RF = \{RF_K, \ RF_F, \ RF_S, \ RF_Y, \ RF_M, \ RF_V, \ RF_K, \ RF_P\}$,

which attributes are codes of the report, base unit forms of company or organization, years, months, executor, manager and sighting condition;

– a set of reporting forms

$PF = \{PF_K, \ PF_F, \ PF_N, \ PF_T, \ PF_{RW}\}$,

which attributes are the parameter of codes and forms, parameter names, type and information required to read and write in the reporting form;

– a set of reported data

$D = \{D_K, \ D_{PF} \ D_{RF}, \ D_V\}$,

which attributes are the codes of data, report and parameters and reporting form significance as well;

– a great number of reporting areas, system users and their groups, reporting forms and their groups, directory of years and months and basic units is denoted by structure relations:

$A = \{A_1, \ A_2\}$,

where A_1 is a unique numeric attribute (key field) of the set, A_2 is text attribute name of describable entity by it.

The model of reporting form list for the period is formed on the basis of a logical expression:

$$M^{<1>}\|P_F, \ P_Y, \ P_M\| = RF$$
$$((RF_F = P_F) \cap (RF_M = P_M) \cap (RF_Y = P_Y)) \to$$
$$\|RF_S, \ RF_V, \ RF_K, \ RF_P\|.$$

The logical-mathematical models of data retrieval by one reporting form on one report form P_F at the billing period denoted by month's parameters P_Y and then P_M can be represented as:

$$M^{<2>} = M^{<1>} \langle RF_k = D_{RF} \rangle \, D \langle D_{PF} = PF_K \rangle PF \to$$
$$\|D_V, \ PF_T, \ PF_{RW}\|.$$

The process of report construction of company over the period for all basic units of the enterprise can be represented in the following model:

$$M^{<3>} = M^{<2>}[PF_T, \ sum(D_V)] \to$$
$$\|R_1, \ R_2\| \{M^{<2>}[RF_P, \ D_V]((RF_T = R_1)) \to |R_3, R_4|\},$$

which permits to consolidate these separate departments of company and the grouping of results by the type parameter.

The process description of the report building for one of the departments over a period is determined by the model $M^{<3>}$, the side condition of the reporting department selection P_s by user is:

$$M^{<4>}\|P_S\| = M^{<2>}[PF_T, \ sum(D_V)](RF_S = P_S) \to \|R_1, \ R_2\|$$
$$\{M^{<2>}[RF_P, \ D_V]((RF_S = P_S) \cap (RF_T = R_1)) \to |R_3, R_4|\}.$$

The process of report constructing by the interval of accounting periods is denoted by four parameters $P_{Y1}, \ P_{M1}, \ P_{Y2}, \ P_{M2}$ (year and month of the beginning and end of reporting period), which indicate the range of reporting forms from the register:

$$M^{<5>}\|P_F, \ P_{Y1}, \ P_{M1}, \ P_{Y2}, \ P_{M2}\| == RF \, ((RF_F = P_F) \cap$$
$$(f(RF_Y, RF_M) \ge f(P_{Y1}, P_{M1})) \cap$$
$$(f(RF_Y, RF_M) \le f(P_{Y2}, P_{M2})))$$
$$< RF_k = D_{RF} > D < D_{PF} = PF_K > PF \to$$
$$\|RF_S, \ RF_V, \ RF_K, \ RF_P, \ D_V, \ PF_T, \ PF_{RW}\| \ ;$$

$f(x, \ y) = x + y/100$. Thus, the logical-mathematical apparatus is developed that permits to make data retrieval by the use of the internal union and outer join, functions of aggregation, sorting and grouping of results, and makes it possible to use the model parameters of subqueries in databases, and realize the information technology of computer systems using automated form turning and its parameter

editing. The computer system template makes it possible to build a software interface with indicating of language preference and user authentication to improve the efficiency of the automation formation of the computer systems of management reporting.

V. Conclusions

The logical-mathematical apparatus of the representation of the models of the automated system of computer system building has been suggested in the article, which unlike the others makes it possible to describe easier the parameters of analysis, processing, aggregating, sorting and grouping and permits to take into account the features of the relationship between entities and define the computing expression and the attributes of result tuples of performing generated routines and subsystem models in general, and that permits to expand the field of the use of logical-mathematical modeling for the automated design of computer systems. The template is built and its structural components of forming the system of management reporting for the monitoring, identification, analysis and data processing are determined.

The control system of power sales reporting was generated by the means of the proposed system of logical-mathematical model consolidation and developed information technology of computer system formation, which is implemented in commercial operation of "Vinnytsiaoblenergo" Ltd. in 2009. The implementation of generated informational and analytical system of management reporting realizes the control and consolidation of indexes, makes it possible to handle reporting with the purpose of increasing the efficiency of management decisions of company management. It permits to improve the efficiency of the organization power sales of the company by consolidating some of its reporting departments and to increase a degree of reliability of reporting information, quality control and management reporting as well.

In the future we plan to continue exploring opportunities of logical-mathematical models for constructing decision support systems, and expand the field of application of the proposed information technology of the formation of computer systems to the other areas of national economy as well.

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