Information System Modelling to Control Transport Operations Process

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***Abstract*— This work describes the development of Enterprise Architect Unified Modeling Language (ea UML) – Microsoft SQL Server – Borland C ++ Builder information model for qualitative operation of open-cast mining and transport systems including description of process, technical and organizational factors influencing on the efficiency of mining and transport operations processes.**

For simulation (imitating) a model of open-cast control is used for research of traffic ACS installation efficiency (Automatic control system of traffic).

***Index Terms*— Automatic control system of traffic, CASE Technologies, Database Management System, Transact Structured Query Language.**

I. Introduction

Successful development of open-cast mining works was largely enabled by process in the sphere of transport of mined rock – the most important process of open-cast geotechnology, determining the efficiency of mining industries operations. In CIS countries, namely in Kazakhstan, Russia and Ukraine, the mining industries will remain the basis of the national economies; thus, the problems of development of open-cast mining and transport equipment as well as properties of creation and study including deep open-cast systems remains a topical task for scientific and technological community.

This work describes the developed information system intended to control the process of mining transport operations based on the satellite navigation and radio modem communication with purpose to improve the quality of traffic controllers' work and shift's tasks performance as well as to improve the efficiency of professional information awareness. Software and hardware are developed to improve significantly the IT penetration level of mining and transport operations process. The sources of information are the following: equipment position sensors based on the satellite navigation and database of open-cast mining and transport system (information on number and kind of mining and transport equipment, shift tasks etc.).

Manuscript received January 6, 2009.

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The data exchange between traffic control point and mobile facilities is ensured by the digital data transmission through radio channel using the radio modems connected to the inputs of radio stations. Data of position and condition of an engine is collected and gathered by the board controller and then is sent automatically to the traffic control point. (See Fig. 1).

The purpose of this work is to develop an information model of open-cast mining and transport system operation taking into consideration all process, technical and organizational factors influencing on the efficiency of mining and transport operations processes.

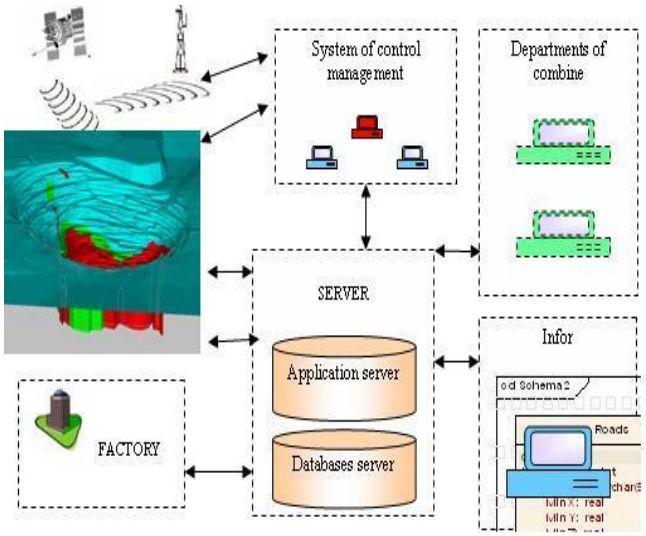

Figure 1. Model of transport operations process control

II. Determination of the Main Indicators of Automobile and Railway Transport Operations

Entrance of vehicles the loading/unloading point is identified by the accuracy of position determination of vehicles. Due to the possibility of determining the position of vehicles with the certain time interval based on satellite navigation, there is the possibility to determine the following data on this basis:

- total passed distance *L* within the observed time (hour, half shift, shift and etc.);
- number of the round and half trips completed by vehicles;
- average operation speed (considering loading/unloading time);
- average technical speed (excluding loading/unloading time);

- total time in movement;
- total time of demurrage (loading/unloading, holding loading/unloading points release, organizational-technical demurrage);
- number of mined rock transferred (per volume, tonnage, types of mined rock);
- direct and specific performance indicators (approximate fuel consumption, tire consumption, ton-kilometers, grams of fuel per ton-kilometer, liters per 100 kilometers and etc.);

Besides, there is the possibility for railway transport to obtain in automatic mode the completed schedule of train movements.

A. Determination of the main indicators of extraction and loading equipment operation.

Even without equipment of satellite navigation and radio equipment on extraction and loading equipment, the following data can be determined per each loading/unloading point:

- number of vehicles served at loading/unloading point;
- volume of mined rock loaded;
- weight of mined rock loaded;
- holding time of loading/unloading points;
- operation time of loading/unloading points;
- direct and specific performance indicators of extraction and loading equipment operation.

B. Control of mining and transport equipment operation.

Control of process operation for mining works can be carried out by two modes:

- by direct visualization on display monitor of dispatcher's work place (or any other display connected via network) of the actual location and move of mining and transport equipment. Note that the actual location of the transport equipment can be visualized by two types: 1. by calculated clearing off the errors of the results of location determined by satellite navigation system; 2. without clearing off the errors in determining the location;
- by reflecting values of the current, final per growing performance indicators of operation of all mining and transport system of open-cast or separate type of equipment, and also by making values of deviation of process parameters from planned, daily, weekly or other indicator of mining and transport complex operation as the table data or the relevant diagrams.

C. Record of mining and transport system operation

Record of the all information coming from process equipment is carried out by accumulation of automatically obtained data in databank. The main task of databank is the reliable record of the coming information per each mining or transport equipment fitted with the relevant devices and, if required, transfer of the required information demanded by subdivisions of the plant.

D. Analysis of mining and transport system operation

The main task of the block of performance analysis of mining and transport system operation of open-cast is to identify the basic indicators of operation of each equipment unit and the whole mining and transport complex as a whole in order to transfer the required performance information first to the block of operative planning, and also to all subdivisions of the plant which require this information.

III. DESIGNING THE DATABASE FOR MANAGEMENT OF TRANSPORT SYSTEM

The developed system shall receive, consider and analyze the obtained information on-line and shall form an information basis for the system of mining and transport operations control and planning [1]. There is an opportunity to obtain the executed train diagram in an automatic mode for railway transportation.

For simulation a model of open-cast control is used for research of traffic ACS installation efficiency (Automatic control system of traffic) [2]. It shows that the efficient control of rolling stock operation will allow reducing almost one and a half time the specific cost price of one ton of mining weight export. It occurs due to reduction of fuel charge and trunks deterioration, e.g. see Figure 2.

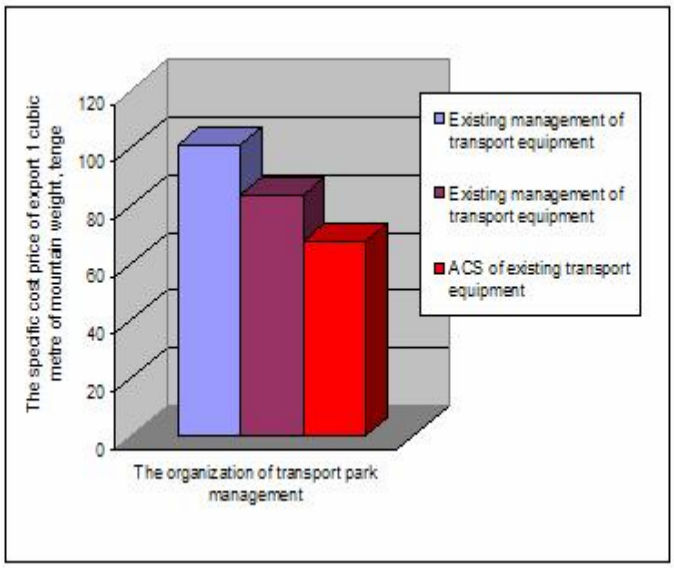

Figure 2. The diagram of efficiency of mining and transport operations imitating model introduction

The developed technique [1] object-oriented system analyses of a range-transport full gallop allows according to the purposes and research problems:

1) to make identification of subsystems and elements making it by allocation of the essential characteristics distinguishing investigated object from all others, and to define its conceptual borders;
2) to make multivariate hierarchical decomposition of an investigated range-transport career and its elements as by construction of static attitudes essences investigated subsystems, and by classification of subsystems of categories of behavior describing dynamics;
3) completely to realize one of main principles system – model representations of complex system with a necessary degree of detailed elaboration of technological process of mountain-transport works.

A. Logic designing of a database

Using of CASE Technologies (Computer-Aided Software/System Engineering) and CASE Tools enabled to

systemize and automate to the maximum all phases of software development. In this work, to ensure the logic programming of database, the CASE Tool ea UML is used, and the "Essence – Communication" model is developed, e.g. see Figure 3. This diagram shows the intuitive review of the project and is especially useful for users to exchange their ideas.

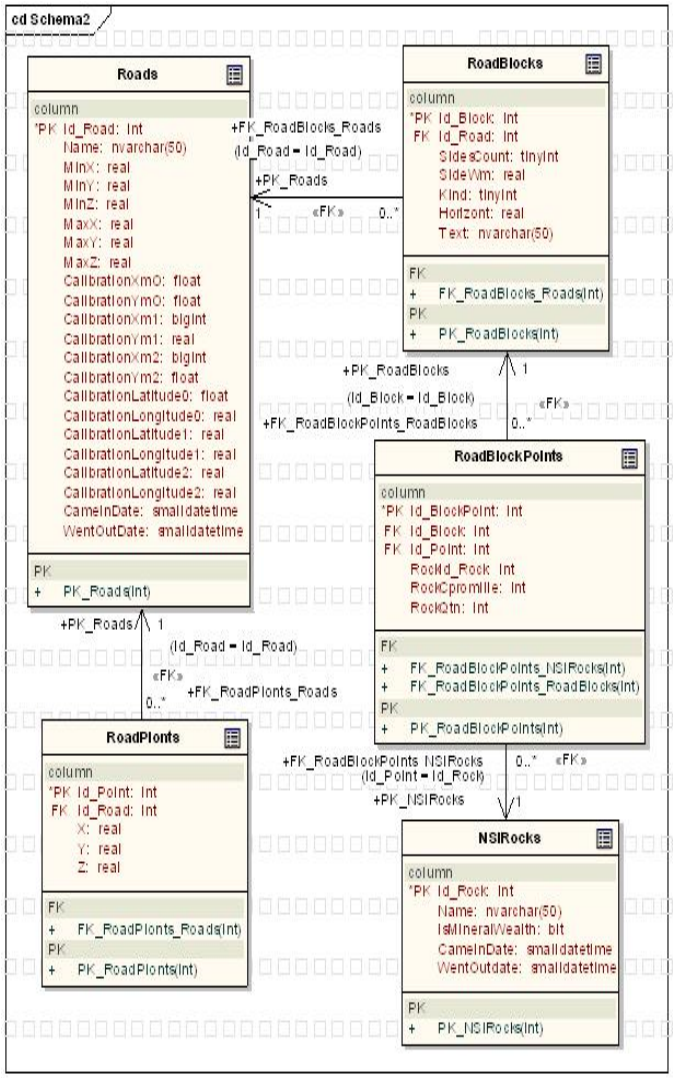

Figure 3. Fragment of the database scheme of a mountain-transport in Enterprise Architect Unified Modeling Language (ea UML).

The next step was the verification of any operational use of organization's data related to the data processing, and the exclusion of all useless and repetitive data. In the process of database design, to solve tasks of data doubling minimization and facilitation of data processing and updating procedures, the relations were normalized. The tables of designed database are in 3rd normal form (3NF) accordingly to Dr.E.F.Codd [3].

B. Physical designing of database

The physical design phase consists of associating of database logical structure and physical environment of storage with purpose to ensure the most efficient data allocation that is the mapping of the database logical structure in the storage structure. The following issues are in consideration: the stored data allocation in the memory space and the selection of efficient methods of access to different components of the "physical" database. Solutions made within this phase make critical impact on the system performance.

The physical design of the database was performed using the professional design package MS SQL Server 2005, e.g. see Figure 4.

The database is also intended to store information but, due to type of most files, makes not the information available directly to the user; the database launches the application which refers to the data stored in the database and makes it available in the format understandable for the user. MS SQL Server has a number of advantages over other DBMS (Database Management System) – easy installation, deployment and operation; scalability, creation of data warehouses and system integration with other server software. Another factor which influenced on the DBMS MS SQL Server selection for this work was the speed. As of the relational databases, the speed is the time needed to make query and to return to the user the results of the query processing.

Runaway of SQL (Structured Query Language) popularity is one of the most important tendencies in modern computer industries. For several recent years SQL became the most popular database-oriented language. Nowadays SQL supports over hundred of DBMS, operating both personal computers and large computing machine.

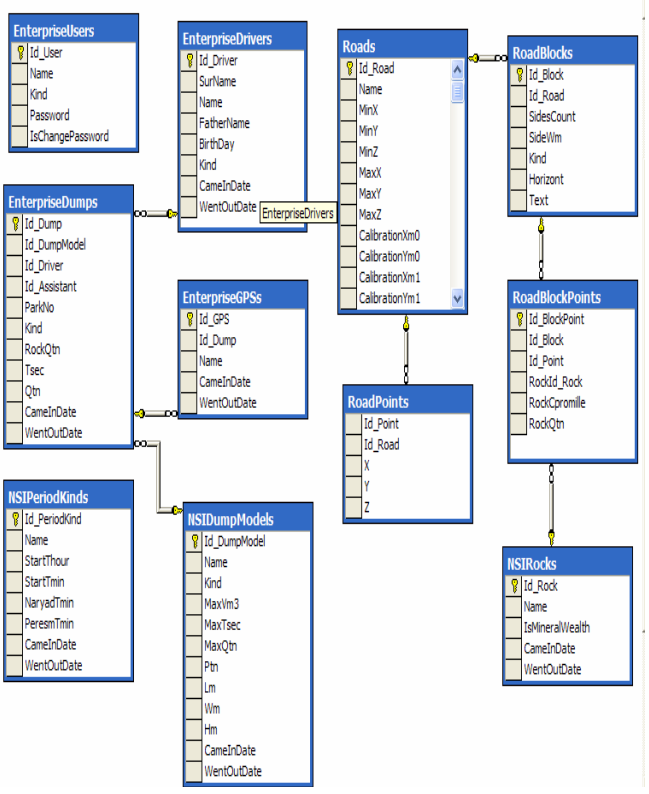

Figure 4. The diagram of a database of a mountain-transport in MS SQL Server 2005.

The user requires reading data from database, it quires them from DBMS using SQL. DBMS processes the query, searches the required data and sends them to the user. While operating with the data, it is supposed to add data into the table, selection, removal and change of data in the table.

One of the most important elements of the database design is the development of the database protection. The protection has two aspects: protection against failures and protection against unauthorized access. The file back-up strategy is developed to ensure the failure protection. To ensure the protection against unauthorized access, each user will obtain the access only in compliance with his/her access rights.

In this work, the protection using SQL Server Tools was organized in standard conditions. The users' accounts are used to control the access rights to specific server resources such as tables and stored procedures. The user account determines one or more roles of the user. The user accounts are created for system access as the user, the user is required to enter Logins in Name field, enter password in Password field, choose SQL Server Authentication, from the list of Database choose ADIS base.

In the course of development of distributed information systems within the organization of user and server parts interaction the following tasks shall be solved: the database carriage to the server for its further sharing as corporate database; organization of queries of the front-end computer to the corporate database allocated on the server; development of client application for remote access of the front-end computer to the corporate database; server administration from the side of the client.

C. Client software development

In this work, in the course of client-server application development, the technology ActiveX Data Objects (ADO) is used to enable the databases operation. ADO technology is based on the object model, in which the objects have sets of collections, methods and features, providing support of database. The objects of the technology provide the widest opportunities on integration of software with databases.

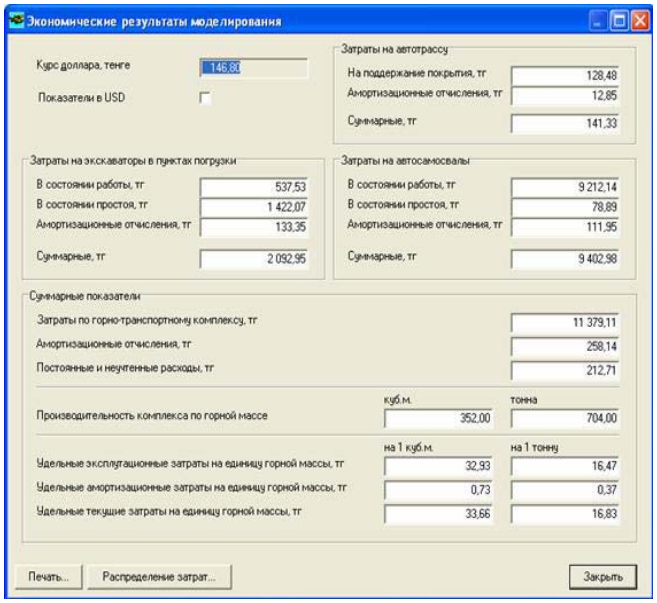

Figure 5. The interface of client application

The Client Software for the database was realized in the visual object-oriented environment Borland C ++ Builder [4], (e.g. see Figure 5). The database processing was organized as follows: data search with changing parameters, results of dynamic queries based on Transact Structured Query Language (TSQL): integrated, crosstab, associated etc.

IV. Conclusion

Within the optimization, the developed information model results in solving of the following tasks: to determine the efficient combination and numerical relation of mining and transport equipment; to schedule the repair works for main mining equipment; to analyze the traffic on the site roads; to establish position, number and optimal parameters for transfer warehouses located within the open-cast site; to assess the economic efficiency of actual condition of mining and transport system with identification of equipment load level and potential improvement of equipment operation due to the improvement of site roads quality, (e.g. see Figure 6) vehicles load factor, selection of optimal mode and conditions of vehicles operation.

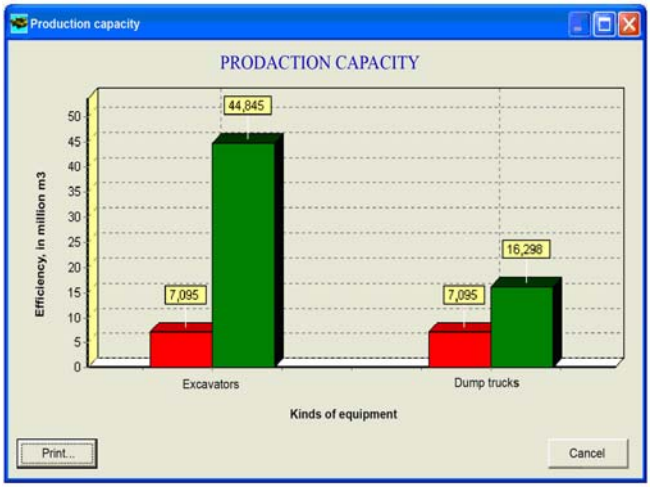

Figure 6. – Technical and economic parameters of mountain-transport open-cast systems: economic results of modelling

The developed information model enables to use the database for management of process complexes of open-cast operating the motor vehicles, to develop the timetable of mining and transport operations and to optimize the main technical and economic parameters of open-cast mining and transport systems.

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