Making an Universal Intellectual Managerial System of Construction Projects and Housing and Communal Services

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Abstract. Optimal planning of construction projects requires efficient allocation of available resources. Labor, materials, equipment should be planned, coordinated and quickly adapted to different conditions. Frequent (design) changes during the construction period, the variety of professions and the high complexity of the interacting processes in the construction industry require innovative ways to support decisions that affect the process—a tool that allows you to test interventions and adjustments in the production process, including individual subprocesses with maximum efficiency. In this context, there is a simulation of discrete events. The research team offers optimization of design, construction and operation of buildings in the new information environment. The authors develop a system of positioning and effective management of the construction object in time and space.

1. Introduction
The key requirements of the efficient functioning and further improvement of the managerial system of national economy are the accumulation, processing, transmission, and storage of vital information. Each managerial function is accompanied with a certain set of documents with the contents depending on the scope of problems on agenda, the volume and nature of the company’s competence, the procedure of decision making, the way it interacts with other companies, etc.

The aim of this article is to estimate the managerial potential of real estate objects during construction and servicing by applying methods of complex information management. With that in mind, we have studied the experience of constructing the innovative universal information system, its functional algorithm, design data, and potential [1-4]. To further the goal, the authors have been analyzing the process of data collection by an advanced information system, its functional algorithm, mathematical apparatus, and operational capabilities. A major feature of the complex under study is the synthesis of not only its managerial construction and servicing data, but also its cadastral information in a single administrative and managerial cycle, which is quite new for an investment-construction complex of Russia [5-7].

2. Materials and methods
A wide-scale application of new computer-based information technologies for storage and processing of huge volumes of information is of high demand today. This is especially urgent for construction industry where real-time building production management requires setting up deadlines, considering times, cycles, and costs. A shift to the automatic data accumulation and processing may facilitate an
increase in the designers’ and managers’ labor efficiency, create some favorable conditions for the consistency of research, enable a wider use of the contemporary methods of mathematical analysis, boost and merge research results with practice. A major advantage of automated databases is a better access and rate of receiving information, its optimal application for scientific, academic, and applied ends, e.g. environmental monitoring, project cadaster compilation etc[5].

Starting in 2007, the authors have developed the ALLROST information system (further "IS"), designed to storage and use the data of the objects of capital construction, the documents from the funds and literary sources of the authorities of the architectural and housing and communal services of the Rostov Region[6-8].

When constructing the IS, we made use of the experience of creating other data retrieval systems in view of developing a long-range industrial regional data retrieval system. Beside treating scientific problems, the IS is intended to boost the efficiency of utilizing software for academic purposes. Such an information system may help graduates in preparing for and taking specialty tests. Moreover, would-be professionals and masters will have a convenient access to some real-life data on whatever construction sphere in the Rostov Region.

The IS relational database has been built on the relational model where each object is entered in a structured table[9].

The relational model we offer to control databases is based on the works of E. Codd. It includes the following:
- data structures (changing in time) as the clusters of relations, e.g. here as the relationships of construction documents in the framework of the organizational managerial system of construction and housing and communal services;
- set-theoretic operations of data: unification, crosscutting, residuation, and Cartesian production enabling to build up an important information content for a specified mode;
- specific rules to facilitate data integrity.

3. Results and Discussions
The ALLROST system contains two basic data units: cadaster data of existing projects and long-term plans of building development, and also some architectural and construction information of each particular project including its operating data[10-13].

The cadaster coordinate system is used to describe the objects’ positions in a city cadaster as well as a cadaster of built-up areas. The system's elements are cadaster inventory units that ensure an uninterrupted area coverage.

Cadaster inventory units are expressed as unit, zone, housing estate, street section, block to make up a hierarchical coordination system, the minimal unit of which is a plot. Inventory units are classified according to administrative-territorial, architectural-planning, and target allocation of lots.

Thus, the mathematical model of the cadaster coordination system is represented as a multitude composed of cadaster inventory units. In other words, its mathematical values can be verified and described using the software, which allows to establish the synchronous state of the object and its dynamic properties[14-17].

The relational constituent of the mathematical model of the program is a set of operators that make use of the relations as arguments and retrieve such relations as results. Thus, the relational operator of the program model looks like a function where relations are expressed by arguments.

\[ R_{\text{base}} = \beta(R_1, \ldots, R_n) \]  

where \( R \) is argument of the singular data of object characteristics viewed as documents and established in the unified system IS.

Thus, in the relational terms used in the software we offer, we can use any imbedded expressions, no matter how complicated their structure might be. This makes the program widely versatile and
applicable while working with cadaster data irrespective of the region, original database, or the type we choose [18-20].

It is well known that relational models suggest the control over data by means of mathematical relations, which narrows up their scope of application. The polyhierarchic model of relations we offer enables to control data by means of relations and also by a set of pointers.

The data of the relational model are presented as tables that are structured typologically and time-wise. The pointer of relations here are categorical typological classifiers and time indices.

In this respect, the IS ALLROST acts as a multiobject and multicriteria system, composed of interrelated subsystems and coalitions that are homogeneous by their physical nature and equivalent by their application function.

Here we realize the principle of a multichannel control of initial data where each resulting document retrieved from the IS gets formed basing on the initial data, verified via its system relations by the parameters determined by the user. These initial parameters are object coordinates, economic, architectural, planning and other data, while their parameters are any required information references about the object.

Reference points get linked to relevant building objects that, in turn, get grouped into cadaster clusters. For each type of categorical cadaster cluster is stored there is provided a storage function for an arbitrary number of objects of cadaster identification with their coordinates and passports. For cadaster classification systems (synchronous and dynamic), we have developed a unified standard that includes the following parameters: reference and administrative (territorial) areas, places of positioning, function, owner, architectural planning features, year of edition, reconstruction history, service history, real estate record.

When viewing the data of a specific object, the program automatically forms and presents an object card including all the data of the object available in the system.

The ALLROST information system provides a few ways of data search, such as:
- position-oriented search;
- ownership search;
- search by real property transactions;
- search by architecture and space planning solutions;
- search by years of construction/commissioning.

To facilitate working with documents, writing reports, articles etc. the IS offers to draw files with alphabetic lists of objects and clusters along with their characteristics.

The ALLROST IS has been developed based on a relational FoxPro DBMS consisting of a database and software. The database contains separate files which, during operation, form relationships.

The leading database file is the positioning file of coordinates. Each positioning description has its own number, systematic level number, and also a reference to its parent. Such a file structure, along with the filtration mechanism, creates a systematic hierarchic structure.

The data of architecture and space planning, economics and other nature are stored in files that are linked to the numbered name file.

The IS provides a number of opportunities in manipulating the data by offering the hierarchic menu with registered roles for users; such roles enable operations within the limits of their responsibilities excluding any illegal manipulations of the data contained in other zones.

The polyhierarchic model of the IS we offer reflects the dynamic and network properties of the controlled documented process of construction as well as housing and communal servicing. Its functional potential is based on the probabilistic criteria of effective self-protection (the topmost function of safeguarding self-protection based on self-management), cybernetics and integral management system IMS (the topmost function of self-management and optimization of management systems) and informatics (the basic condition of system resilience). In particular, in the absence of limiting the affinity of representations, where each compartment is of scalar nature, and the right part
of the system, beside its own dynamics, there is just the dynamics of "inflows" and "outflows" down network links, the description in the space of compartment conditions looks like the following:

\[ x_k = f(x) + \sum_{j \neq k}^{n-1} x_j \]  

(2)

where \( k = 1 \ldots n \), i.e. index of verified system data

If compartment \( x_k \) is vector, it is related to a few transitory states \( x_k \), \( x_{k1} \), \( x_{k2} \), \( \ldots \). This expression characterizes the system's stability that depends on the objective presence of data, i.e. is self-sustained.

The realization of the management structure within the framework of documented processes as expressed in the algorithm of the IS operation may be presented as follows:

![Diagram](image_url)

**Figure 1.** The scheme of the optimal interaction.

where the IMS (integral management system) is the basic data processing algorithm that initiates verification of data from the angle of collecting, processing, and realization. The MMS (management monitoring system) is the level of linear processing at the primary managerial level. In this algorithm, the data gets systematized both along its relationships within the base and their position in the actual topographic data of the locality. The number of parameters is specified depending on the classification constituent of the IS. The CDSS (current data summary system) is the level of specification of the construction project.

The polyhierarchic model suggests equality of the leading algorithms that verify the data in the final document. Moreover, the hierarchy of the algorithms gets preserved and each lower-order algorithm is subordinate to the high-order algorithm.

4. Conclusions
Management in the new environment allows you to clearly structure objects. Link them to a specific location and optimize the cost of their operation.

The most suitable option can be chosen from various options for the construction sequence, and the process of building construction can be planned in the most favorite way. Thus, modeling is an important tool to support construction production during the planning and execution of production. The conducted simulation study showed that the necessary technological input data for such a detailed production planning does not exist in practice today. The collection of these data for modelling purposes is an essential and very important task to obtain benefits for the construction industry.
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