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Implementation of Data Structure for Digital Representation of Building Model

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***Abstract*—This paper is dedicated to one part of the building lifecycle automation problem. The article is focused at the data structure development for digital representation of building model. We have suggested separate invariant meta-database and core of digital representation model of building.**

***Index Terms*— Building Lifecycle, PLM, BIM, Building Model, Digital Representation and Database**

I. INTRODUCTION

THE problem of building lifecycle modeling automation still is relevant. Nowadays there are lots of different solutions in this field, but all of them do not provide exhaustive solution of the problem.

Today, the generation and management of digital representation of buildings called Building Information Modeling (BIM). In fact BIM is the subtype of the Project Lifecycle Management (PLM) in construction. The BIM term includes processes which arise during planning, designing, constructing, operating and maintaining diverse physical infrastructures [3]. In addition, the BIM term includes software solutions used for building lifecycle automation (Fig. 1).

One of the common problems in BIM is developing of effective data structure for storing digital information about building. To handle this problem, firstly we need to do a deep research of a building lifecycle. Such kind of research has been done in some previous woks, thus we just do quick survey of its. And in this paper we concentrate our attention at implementation of the data structure for digital representation of a building.

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Fig. 1. Building Information Modeling (BIM)

II. PREVIOUS WORK

There are several works related to building lifecycle modeling in general.

The works [1], [2] are related to Computer Aided Design (CAD) and are considered as predecessors of the BIM term.

The paper [5] presents building model conception which describes basic stages of building lifecycle and their common parts.

The paper [6] is considering possible data structure architecture for storing digital information about building representation model at each stage of its lifecycle.

The article [9] is dedicated to problem of PLM in construction and describes main stages of building lifecycle, corresponding tools and executors for each stage.

III. DIGITAL REPRESENTATION OF A BUILDING

The digital representation of a building should consist of several clusters. Each of clusters describes a part of building lifecycle information. The common information clusters are: geometry, topology, time and finance. The fragment of a data structure core is presented at Fig. 2.

The base data structure of BIM core is describes building object as digital model. At the top of hierarchy we have table with all stories of a building (Stories). Each story consists of construction elements (table Elements) either directly or as part of zones (table Zones). In fact, between construction elements we have direct connection (inclusion) and between elements and zones we have reference connection (link).

Each construction element should have structure (table Structures) – it can be simple or complex material (table Materials) or group of materials.

The tables which describe elements geometry is the most important. All of them are connected with table Geometries that is aggregator of different geometric structures and have direct connection to elements.

The Fig. 2 contains only several 2D and 3D geometry shapes. The 2D shapes are: lines, triangles, polygons, nets and triangular irregular networks (TIN). The prism is only one presented 3D shape but the list of 3D shapes can be significantly extended.

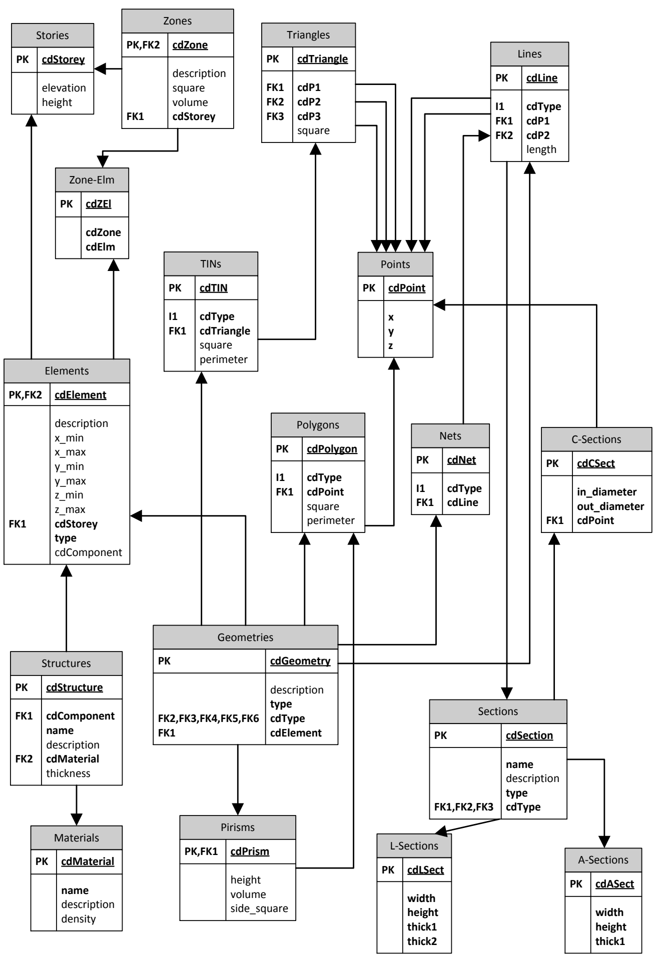

Fig. 2. The fragment of data structure

We should emphasize that lines have additional attribute – section type. We depict only three types of sections at Fig. 2: circle, angle and L-section.

The presented fragment of data structure is base version and it should be extended during developing process. But even base version is applicable for complex building describing.

In case of adding new element or section types it is enough to create new tables and connect them with related aggregators.

IV. INVARIANT META-DATABASE

Many building objects have a similar set of construction elements. That is meaning that some components of their digital representation will be the same. For this reason we need to have invariant meta-database with typical building elements, section types and financial information about it.

Invariant meta-database can have several implementations as the set of physical databases using different database management system (DBMS).

The common model of invariant meta-database consists of next references: typical construction elements; typical geometric shapes; list of common materials; measurement units; list of prices for materials, machines and jobs etc. (Fig. 3).

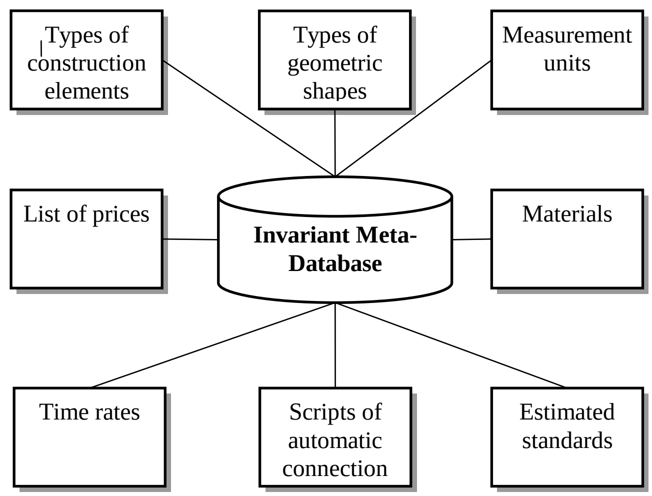

Fig. 3. Typical structure of invariant meta-database

From implementation point of view, it is logical to separate estimated standards, list of prices, time rates and scripts of automatic connection into single databases. It allows to create model of each building object very flexible and with option to have a several final implementations based at the same architectural solution.

The suggested typical structure of invariant meta-database is not full, but only common part. For each specific BIM system it needs to add new features, entities and attributes inherent to specific stage of building lifecycle.

For instance, possible structure of invariant meta-database for estimation system can be designed like presented at Fig. 4.

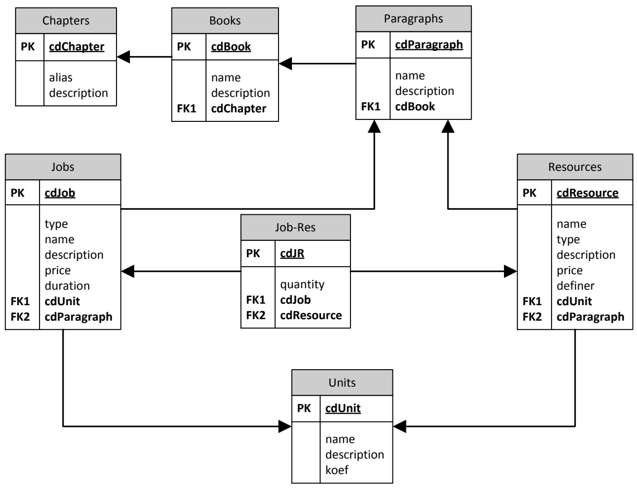

Fig. 4. Example of typical invariant meta-database for estimation system

Typical invariant meta-database for estimation system consists of chapters. Each chapter includes books, and each book consists of paragraphs. Such structure currently used in our home country.

The paragraphs consist of jobs and resources. Material, equipment or machine/mechanism can be treated as resource. Each resource has measurement units and price.

Job is kind of complex resource that consists of simple resources and employees salary. Different jobs can consist of the same resources, thus they have relation type many-to-many. To handle this there is table "Job-Res" is added to invariant meta-database structure.

V. CONCLUSIONS

This work describes the basics of building lifecycle modeling. We have suggested implementation of a building digital representation data structure. We have separated invariant meta-database and core structure of digital representation model of building.

Our future work is creating conceptual model for data structure at each stage of building lifecycle and to research the common methods for data structure optimization for the sake of effective data usage during building modeling.

REFERENCES

[1] S. Ruffle, "Architectural design exposed: from computer-aided-drawing to computer-aided-design," Environments and Planning B: Planning and Design, 1986, pp. 385-389.

[2] R. Arish, "Building Modelling: The Key to Integrated Construction CAD," CIB 5th International Symposium on the Use of Computers for Environmental Engineering related to Building, 1986.

[3] G.A. Van Nederveen and F.P. Tolman, "Modelling multiple views on buildings," Automation in Construction, vol. 1, issue 3, 1992, pp. 215–224.

[4] Y. Borodavka and M. Tsiutsiura, "Binary Data Packing Method for Database Optimization," International Journal of Science and Research, vol. 3, issue 11, 2014, pp. 903-905.

[5] Y. Borodavka and M. Tsiutsiura, "Building Model Conception," in Proceedings of the WORLD Science Conference "Science and Education – Our Future," issue 3, 2014, pp. 53-55.

[6] Y. Borodavka and O. Kryvoruchko, "Conceptual Model of Data Structure for Building Object," in Proceedings of the WORLD Science Conference "Scientific and Practical Results of 2014. Prospects and Their Development," issue 4, 2014, pp. 37-40.

[7] Y. Borodavka, "Modified R-Tree," International Journal of Science and Research, vol. 4, issue 1, 2015, pp. 1725-1727.

[8] Y. Borodavka, O. Lisovyi and D. Deineka, "The Hardware Adapted Ray Tracing Algorithm," International Journal of Computer Science and Telecommunications, vol. 7, issue 4, 2016, pp. 1-7.

[9] Y. Borodavka and S. Pechenov "Product lifecycle management in construction," East-European Journal of Enterprise Technologies, vol. 48, issue 6, 2010, pp.31-34.

[10] S. Tsiutsiura and Y. Borodavka "Methods of Object Models Mapping into Data Structure," Management of Development of Complex Systems, vol. 21, 2015, pp. 92-98.

[11] M. Abadi and L. Cardelli. A Theory of Objects. Springer-Verlag, 1996.