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The Internet of Things and Building Information Modeling for a Digital Revolution in Construction Design

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Abstract
The challenge of digital transformation in the building sector is the focus of this research. The authors provide a novel method for methodically approaching digital modeling of a construction company's design. A comprehensive analysis is conducted on the digital modeling in design activity that results from integrating Building Information Modeling (BIM) with the Internet of Things (IoT). It is suggested that refurbishment projects use building information modeling (BIM) to include a lifecycle management system for construction products. It is shown that the Internet of objects (IoT) must go beyond "smart things" to "smart planet" in order to be practical.The four main parts that make up the BIM platform are detailed. The study's end product is a digital project management firm model for building object life cycle management.

Keywords 1
Construction design, digital transformation, Building Information Modeling, BIM, Internet of Things, IoT, Big Data Analytics, Blockchain

1. Introduction

2. A system of algorithms for information flows and organizational relationships between project participants and the real estate market in an integrated information environment is being developed as a solution to digital control problems as part of the digital transformation of the economic structure [1, 2]. Digitalization and the widespread use of digital technology for production management and organization are happening at a rapid pace across all sectors and nations. At first, these procedures were separate and evolutionary, automating certain steps in the manufacturing cycle [3]. Regardless of sector, production details, or regulatory particular, the formulation of plans for the digital transformation of company activities is now a top priority for the majority of big enterprises. State projects for the digital transformation of the economy are also responsible for the implementation of information technology for production management in several nations. Some examples of such initiatives are the National Digital Economy in Australia, the Innovate UK program in the United Kingdom, the German Industry program, the strategic concept for the growth of production in China, and the American Advanced Manufacturing Technology program [4-6]. There is an immediate need to reevaluate the purposes of information modeling and create methods that center on the development of long-term information models of a capital construction object, its structure, and the management of its life cycle in the investment and construction complex, given the emergence of new conditions and digital opportunities at both the corporate and industry levels. The most popular methods for building information modeling (BIM) have been around since the early 2000s, and their application has been described in works[7,8] as a means

to address the challenges associated with this practice. However, up until this point, the majority of BIM users have been primarily involved in visual 3D model editing. Practically speaking, building information modeling (BIM) technologies seldom make use of their full potential, despite the fact that they provide information exchange functions for BIM models and other advantages to construction firms and the state overall. Articles [9–11] provide an in-depth analysis of the needs in the building information modeling (BIM) sector, outlining how standards, rules, and codes of practice are created independently according to various degrees of development and BIM integration. A building information modeling (BIM) platform is currently in development for use in management with the goal of managing the life cycle of construction items. This platform will interface with other information systems to guarantee urban planning activities. The model of the building object was created as an archive of data that was not well organized, using these guidelines as a guide. These archives are termed information containers. Books and catalogs detailing buildings and their components are the primary source for this information on the current structure of these capital construction items [12, 13]. The information container relies on internal closed proprietary data formats, which introduces substantial hazards to this modeling technique. This program is designed to be used with other proprietary formats. Consequently, capital construction becomes more reliant on information modeling of building and structure operations based on this. One challenging issue is the structure of construction information. There has not been a standard method for constructing a construction data classifier up to this point. A lot of people in the professional community and in trade groups have something to say about the current versions [14]. A lack of fundamental library components that account for the life cycle of elements in reference books and classifiers, as well as an incomplete resource composition of prices and processes that prevents automatic calculation of construction resource costs and examination of construction costs, are the most significant shortcomings.

The information container model also has a number of concerns, one of which is the issue of open data transfer between the various project participants' information systems and across the various phases of the project's life cycle. The building project's lengthy total life cycle and its exceptionally big and varied number of participants are the root causes of the issues. This adds a new dimension to the information model of a capital building object: the demand for sufficient data reflection over many transformations and over an extended period of time [15].

So, the state should get its conceptual solution in an open format that isn't dependent on any one developer. This is because the state has set the task of developing construction information modeling and the strategic goal of developing a unified federal system for managing capital construction facilities based on information modeling technologies. Simultaneously, the capabilities to include and convert various data formats should be built into the proposed industry digital platform for use all through a construction site's strategically justified life cycle.

In order to maximize the effectiveness and efficiency of building information modeling (BIM) technology deployment, it is necessary to establish an integrated structure that consolidates the acquired knowledge and professional skills [16].

A unified systematic approach to industry information modeling technologies and the development of suitable comprehensive concepts and standards is urgently required, according to the overall analysis of the situation in the work [17] reports. This request has been made in the professional environment. So far, the regulatory and technical documentation for information modeling of capital construction items has been developed

in a disorganized and isolated fashion.
So yet, no universal agreement on data standards has been reached. The construction industry's informatization has not been conducted in a unified manner, with a focus on addressing practical difficulties.

There is a lack of tailored, comprehensive answers. If the construction sector is to continue its digital revolution, it must:
first, come up with a unified long-term goal for BIM; second, organize and clarify the reasoning behind information modeling standards within the context of national and other standards;
3. figure out how to set up a standardized system for building and structural information modeling;
4. back up realistic methods and the process for developing this system.

3. Main research

The authors present systematic approach to digital modeling of the design of a construction enterprise. Fig.1 shows system engineering of digital modeling in design activity.

SUBJECT OF THE DIGITAL MODEL	LEVEL OF THE DIGITAL MODEL	OBJECT OF THE DIGITAL MODEL

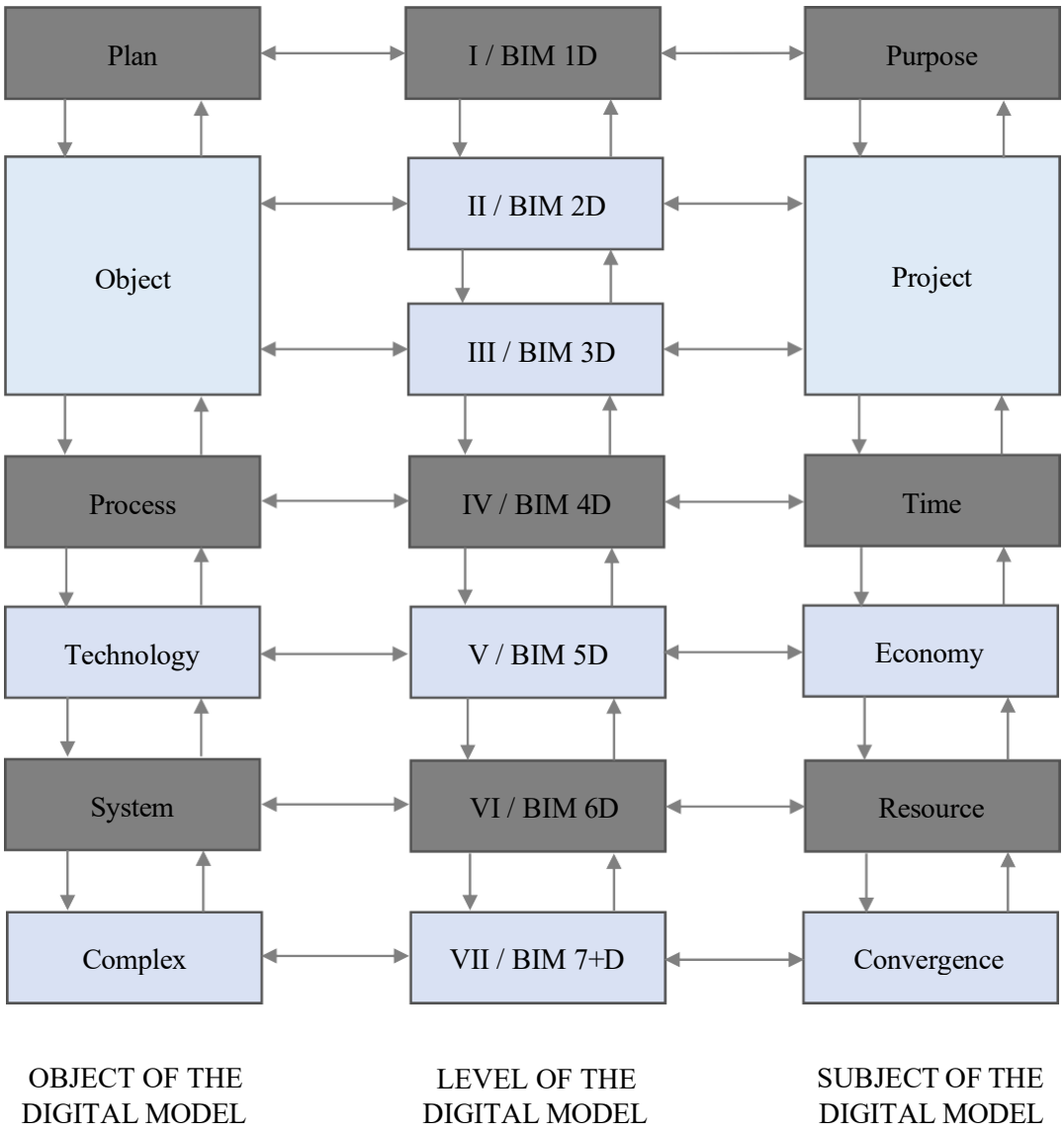


Figure 1: System engineering of digital modeling in design activity

Within the cybernetics paradigm of problem-oriented modeling, the given logical-semantic scheme abstractly distinguishes the principal subject-object (object-subject) horizontal connections of the constituent elements, with the correspondence of each pair determined by its own level of digital modeling.

In the first level of digital modeling, known as level I, subject-object relationships are formalized. This is done by using a simple, arbitrary, or established format and providing a description that directly correlates a set of goals with a set of plans. A conditionally symmetric subject-object connection (the bottom line of the names of the verticals of objects and subjects in Fig. 1) flips the scheme of priority of correspondence such that a set of goals is associated with a set of plans, as opposed to the inverse object-subject connection, which assumes that goal correction influences implementation plans. The digital modeling of creative activity system that is being provided here creates a conditionally direct correlation between the digital modeling levels and the BIM dimension levels in order to keep the overall logic of the scheme simple from a conceptual standpoint. Accordingly, the initial level of building information modeling (BIM) corresponds to the first level of digital modeling (I). The seven levels of the system engineering scheme for digitally modeling creative activity correspond to the six levels of aggregation of entities in terms of subject-object (object-subject) relationships: "plan-goal," "object-project," "process-time," "technology-economy," "system-resource," and "complex-convergence."

In the second (II) stage of the project, two-dimensional models of an item of creative activity are formalized, and in the third (III) level, three-dimensional models are formalized. For any given reason (such as a typical project), when an object is created based on a design priority, the conventionally symmetric subject-object relationship changes the matching priority scheme to the opposite. In contrast, a reverse object-subject relationship makes the object itself subject to a set of design conditions and constraints. Keep in mind that the "object-project" relationship at levels II and III of digital modeling is foundational for intelligent parameterization of the project, design, and optimization of variants, in addition to two- and three-dimensional object visualization.

Level 2 (2D) and Level 3 (3D) of the Building Information Modeling (BIM) hierarchy describe the second (II) and third (III) digital modeling tiers, correspondingly.

The time required to complete the steps that comprise creative activity is codified at the fourth (IV) level. When a set of processes is formed based on conditions and time constraints, such as the fixed terms of commissioning of critical infrastructure objects, inverse object-subject communication takes these constraints into account and reverts to a conditionally symmetric subject-object communication scheme, which changes the order of correspondence to the opposite. Their thorough description of a particular collection of tasks (production, organizational, management procedures, etc.) is the core of the "process" in the concept.

Level four of the Building Information Modeling (BIM) system is analogous to level four of digital modeling (IV).

An evaluation of the associated costs formalizes the technologies used in creative activity at the fifth (V) level. When technological schemes are formed based on financial conditions and restrictions, such as the availability of one technological equipment, reverse object-subject communication changes the scheme of the priority of correspondence to the opposite, while conditionally symmetric subject-object communication assumes that economic conditions and restrictions directly influence the technologies used.

The fifth level of building information modeling, or V-level, is the fifth level of the 5D system. By combining all sorts of resource support for creative activity, which were introduced at earlier levels of digital modeling by time and economics, the sixth level (VI) formalizes the considered items, processes, and technologies that comprise building systems. When building systems are formed in response to conditions and resource constraints, such as when building in the face of interruptions in the supply of building materials or a lack of qualified personnel, the inverse object-subject connection takes these constraints into account and shifts the scheme of the priority of correspondence to the opposite. Similarly, the conditionally symmetric subject-object connection flips the order of connection. A "building system" is defined as a limited collection of interrelated functional components (elements, objects, construction complex) assigned to a certain objective within a specified time period; this

description is consistent with the scheme's central "system" concept [1]. Whether they are material, technological, labor, organizational, etc., "resources" boil down to a comprehensive description of a particular set of tasks.
The sixth level of building information modeling (BIM) relates to the sixth level of digital modeling, which is level VI.
At the seventh (VII) level, a new class of convergence-oriented digital models is formed by combining the building systems that make up creative activity into complexes that further incorporate qualitatively diverse systems, such as social or ecological [9]). For complexes that are considered to be qualitatively different from one another, the inverse object-subject connection assumes that these systems have an impact on those complexes. On the other hand, when complexes are considered to be conditionally symmetrical, the priority of correspondence changes to the opposite, meaning that complexes of building systems, regardless of their positioning relative to the complex under consideration, are significantly affected by these systems (e.g., the impact of the geopolitical situation on dependent construction projects).
It is worth mentioning that at this level of digital modeling, the analysis and solution of most of the tasks of the new creative activity stage (stage 4 in Fig. 1) are defined in terms of convergence.
Level seven (VII) of digital modeling is defined by an expanded seventh (7 + D) level of building information modeling (BIM) dimensions. This level of digital modeling refers to the qualitative convergence of system components with different properties (8D, 9D,..., ND), but it is objectively limited by the real state of society's scientific, technical, and social progress, as well as by the objectivity of necessity and basic common sense.
The current framework of the six levels of entity aggregation in terms of subject-object (object-subject) relationships: "plan-goal," "object-project," "process-time," "technology-economy," "system-resource," and "complex-convergence" has objectively exhausted any scaling of the I-VI levels of digital modeling and the corresponding BIM dimension levels.
Objects, objects, and the logic of the digital model itself randomly link all layers of the system engineering of creative activity that is depicted.
Connecting to digital modeling systems outside of the complex in question is possible at every level of digitally modeled creative activity (like weather forecasting).
In many entirely practical areas of innovative development and construction industry regulation, the described approach to building subject-object and object-subject direct and feedback links at the model level allows one to correctly understand the essence and revise the emphasis.

4. Integration BIM and IoT

The most promising, reliable and meeting all the requirements way to achieve these goals is the use of BIM technologies. The concept of BIM technology is in the stage of deep development and is distinguished by the use of information technology in the construction industry. The fields of application, methods and specificity of the concept are rethought by different experts and scientists from different points of view with different fields of research. BIM technologies are interpreted in different ways: as integrated building models, virtual building models and models of individual buildings. That is why, at present, the definition of BIM technology does not have a uniform interpretation at the international level.

The concept is based on the relevant information data of the construction project as the basis of the model, establishes a 3D information model of the construction project and simulates the real information that the building receives through digital information modeling [18].

BIM technology has many features such as visual analysis, collision checking and construction schedule simulation. With the established BIM model, solar radiation, ventilation and lighting of buildings can be modeled to determine the most appropriate location and spacing of buildings, and to formulate reasonable structural design schemes and scientific approaches that effectively reduce the energy consumption of a building [19].

The concept of introducing lifecycle management system construction objects using BIM implementation in directions renovation projects presents in the Table 1.

Table 1
The concept of introducing lifecycle management system construction objects using BIM implementation in directions renovation projects

Directions	Description
First	Formation of the legal framework of implementation of life cycle management of buildings and structures with the use of information modeling
Second	Implementation of the construction information classifier and ensuring its interconnection with existing international and national classifiers
Third	Formation of methodological, regulatory and technical foundations for managing the life cycle of buildings and structures using information modeling
Fourth	Introduction of modern technologies and platform solutions that support business processes, state functions and public services within the lifecycle management of buildings and structures with the use of information modeling
Fifth	Formation of legal, technological and organizational foundations for the exchange of data and ensuring their reliability and relevance in information resources that make up the digital ecosystem for managing the life cycle of buildings and structures using information modeling
Sixth	Development and implementation of professional training programs for specialists in the field of information modeling in construction
Seventh	Development and implementation of performance indicators of the life cycle management system for buildings and structures using information modeling
Eighth	Development and implementation of performance indicators for renovation projects of territories (residential areas), including complexes of buildings and structures using information modeling
Ninth	Strategic planning of the resource base for current and major repairs in order to extend the life cycle of buildings within the predicted time frame using information modeling
Tenth	Development and implementation of indicators of investment attractiveness and efficiency of renovation projects of territories (residential areas) using information modeling for the state and for business in the long term

Fourth direction of the concept for the implementation of a lifecycle management system for capital construction objects using information modeling technology, taking into account the proposed additions, which we considered earlier, provides for the introduction of the latest technologies that support business processes, government functions and public services within the framework of building and structure lifecycle management using information modeling. Within the framework of this direction, it is advisable to integrate BIM and IoT as an actively developing area of Internet infrastructure development in the world, providing enhanced connectivity of devices, systems and services and their interaction with each other.

Integrating BIM with real-time data from IoT devices is a powerful paradigm for applications that improve construction and operational efficiency. Numerous applications enable real-time data streams from the rapidly expanding set of IoTs for high-fidelity BIMs. However, research on the integration of BIM and IoT is still at an early stage, it is necessary to understand the current situation of the integration of BIM and IoT devices [21].

In essence, construction is project management. With digitalization, it turns into control based on

data obtained automatically at the point of their origin from IoT devices and sensors, connected machines, platforms and equipment, which allow creating information and mathematical models and

algorithms, and realizing more and more autonomous production and business processes having the property of adaptability. That is, the basis for digitalization of construction is informational and mathematical modeling of end-to-end processes, which allows to optimize work in terms of cost, timing, business sustainability and minimization of negative environmental impact, and any other specified characteristics, based on high quality data (in terms of parameters – relevance, accuracy and completeness). So, for almost 30 years of IoT development, according to a number of experts, 4 evolutionary stages have passed [21]. Let's present them in the Table 2.

Table 2
Evolution of the Internet of Things

Stage	Stage characteristics	Example
Stage I – Smart Things	Identification of each object is carried out separately. One fact remains unchanged - a person is needed to connect all objects. It was at this stage of development that the idea of effective interaction between all objects appeared.	health of the planet and the possibility of improving it; people will be able to
Stage II – Smart Building	A system of connected devices and objects that have the ability to communicate. The ability to delegate a significant part of your daily routine to the Internet of Things.	
Stage III – Smart City	Collective image. It shows a situation where every house will become smart. In other words, the prototype can be implemented if IoT technologies become available to everyone. The collection of individual nodes will create an infrastructure in which all objects will communicate with each other. Provides for the collection and processing of all information related to the inhabitants of the settlement, as well as individual districts, quarters and houses.	
Stage IV – Smart Planet	Sensory planet. Acts according to the example of the third level, but already on the territory of the entire planet. When humans can create an ecosystem of smart things, it's time to shift their focus to Earth. With the help of a system of sensors, humanity will be able to control absolutely all natural processes. It will be possible to avoid the consequences of natural disasters; a base will be formed to track the	

Indoor humidity data over a period of time; information about insufficient amount of washing powder in the machine.	in the house, from the refrigerator to the curtains, is connected to each other, the level of illumination and temperature is regulated thanks to sensors and smart watches. The devices are able to make independent diagnostics, as well as inform about the need for repair work. All residential areas are under the control of a general analysis of the data that comes from things. Thanks to this feature, electricity consumption is regulated; various breakdowns are recorded and eliminated as quickly as possible.	urban transport to the regulation of commodity and retail relations is shaped by the collection of data. Ultimately, the standard of living rises.
Everything	A smart city is an ecosystem in which everything from	All cities and countries, all populated and uninhabited areas of the planet are under the control of a general data analysis that comes from things. Thanks to this opportunity, the consumption of natural resources is regulated, the negative consequences of dangerous natural phenomena are recorded and eliminated as quickly as possible, and possible disasters are prevented.

effectively track, control and use resources.

Practical applications of IoT in the construction industry range from smart thing to smart home. The implementation of IoT in construction is complicated, among other things, by the need to take into account the impact on the environment, close ties with housing and communal services, energy and consumer electronics. Based on this, it is possible to determine the current areas of application of the IoT in this area.

A serious advantage of the integration of BIM and IoT is that the Internet of Things is being introduced not only during the operation of the building, but also directly in the design and the stage of construction work.

The integration of BIM and IoT in smart building spans different areas, uses an integration approach in the implementation process that includes a range of cutting-edge technologies, and faces a range of opportunities and challenges. After analyzing this information, it is possible to determine the level of awareness of the population with the possibilities of Smart Construction, to understand which modern technologies used and developed in the world are advisable to invest funds, thereby providing themselves with real competitive advantages. The analysis will focus on those devices of the IoT world, the implementation of which will most significantly strengthen the company's position in the market. And the integration of BIM and IoT, in turn, will provide a synergistic effect.

Fig. 2 presents the key aspects of BIM and IoT integration in smart construction. In our opinion, first of all, it seems necessary to analyze the preferences of potential consumers. Consequently, in the process of new construction, as well as in the framework of the reconstruction of residential areas, builders and developers are invited to use the following scheme to determine the promising directions of the company's development.

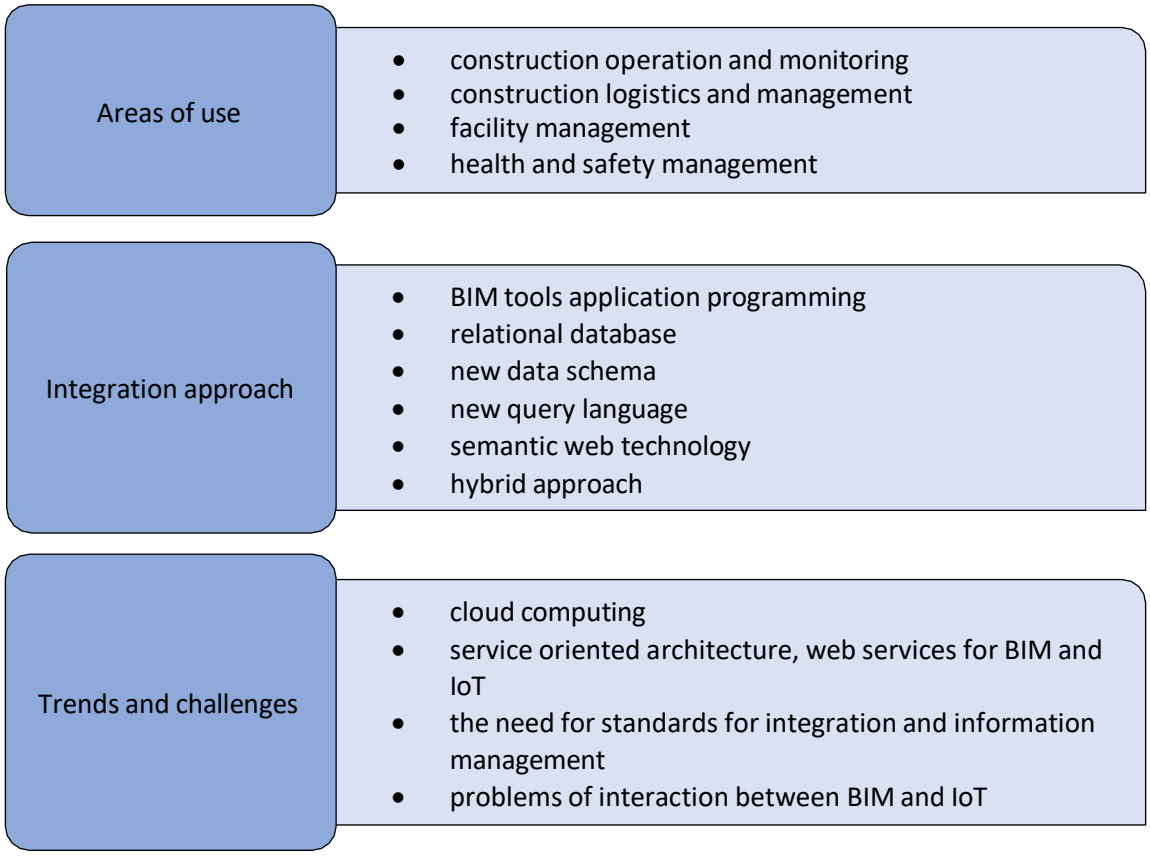


Figure 2: BIM and IoT integration in smart construction

5. Results

Information characterizing a capital construction object appears, replenishes and transforms during all stages of its life cycle – design, construction, operation and liquidation of the object. In fact, this is an information flow, therefore, the structural information model of organizing and managing the life cycle of a construction object can be represented as a set of interrelated information flows of project subsystems. The functionality of digital transformation of organization and construction management is determined, on the one hand, by the growing capabilities and tools of information and communication technologies, and on the other, by the specifics of information flows in construction [18].

Consolidation of many algorithms, tools and approaches of IT technologies leads to the formation of completely new conditions and opportunities for organizing and managing processes in the industry, determines the essence and strategy of changes in the corresponding information flows and forms their new infrastructure.

Let's single out the information and communication technologies that are closest to the industry-specific tasks of information modeling. Fig. 3 presents basic structure of the BIM platform.

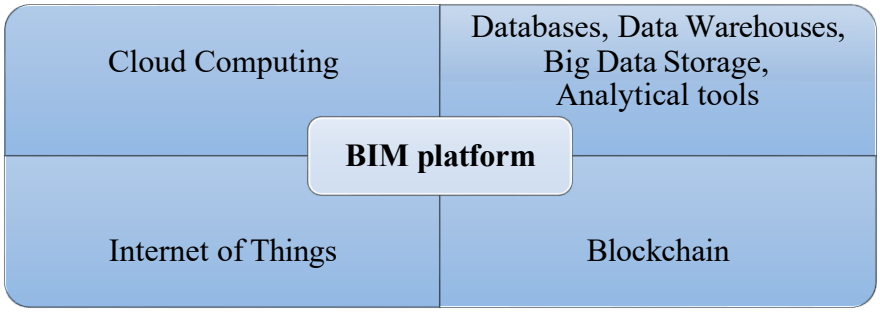


Figure 3: Basic structure of the BIM platform

Firstly, these are cloud computing technologies, which make it possible for numerous project participants to work with project information from different devices with minimal effort to manage their interaction. Cloud services, such as Iaas, PaaS, SaaS, and the like, are currently based on technologies for sharing resources in business processes. Secondly, these are Big Data technologies that use horizontal scaling software tools to analyze and synthesize very significant amounts of diverse data from different sources. It is important that the tasks of organizing and managing the life cycle of a construction project are characterized by varied and unstructured source information. Standard methods and tools for working with data do not allow solving management tasks of this level, and tools and methods of big data in relation to project lifecycle management correspond to the specifics of information flows of a capital construction object. Big Data software products and methods make it possible to work with different, independent and often unstructured arrays of direct and indirect information related to the project, as well as to analyze significant amounts of data from different project subsystems, the information of which is growing, stored and updated with different frequency and speed. To date, leading developers have created many software solutions for big data processing. There are programs from Microsoft, Oracle, IBM, Hewlett-Packard, EMC, Apache Software Foundation (HADOOP), etc. [19, 20].

Another digital concept is the Industrial Internet of Things (IIoT) [21]. The essence of the concept is the unification of engineering developments for equipping with sensors and online connection of structures and devices. Their integration provides instrumental monitoring, organization and management of production processes in real time, remotely and automatically. The digital IIoT concept of the industrial Internet of Things is already forming the infrastructural basis of information flows for the organization and management of the project life cycle.

In the context of the openness and security of the format for managing the life cycle of a

construction object, it is also advisable to consider the applied prospects of digital Blockchain

technology [22, 23]. This technology is rapidly expanding the scope of various applications. The Blockchain functionality is designed in such a way that:

- information exists in a distributed network built and maintained by network users;
- data are copied in multiples, which ensures maximum stability and security of data storage;
- all information has an open history, which allows to control the authenticity and origin of the data.

Taking into account the specifics of the information flows of the project life cycle in construction, the implementation of these functions is necessary and extremely in demand in the information management model.

Fig. 4 shows a model of the proposed system architecture based on integration of BIM, IoT, Big Data Storage, Cloud Computing and Blockchain.

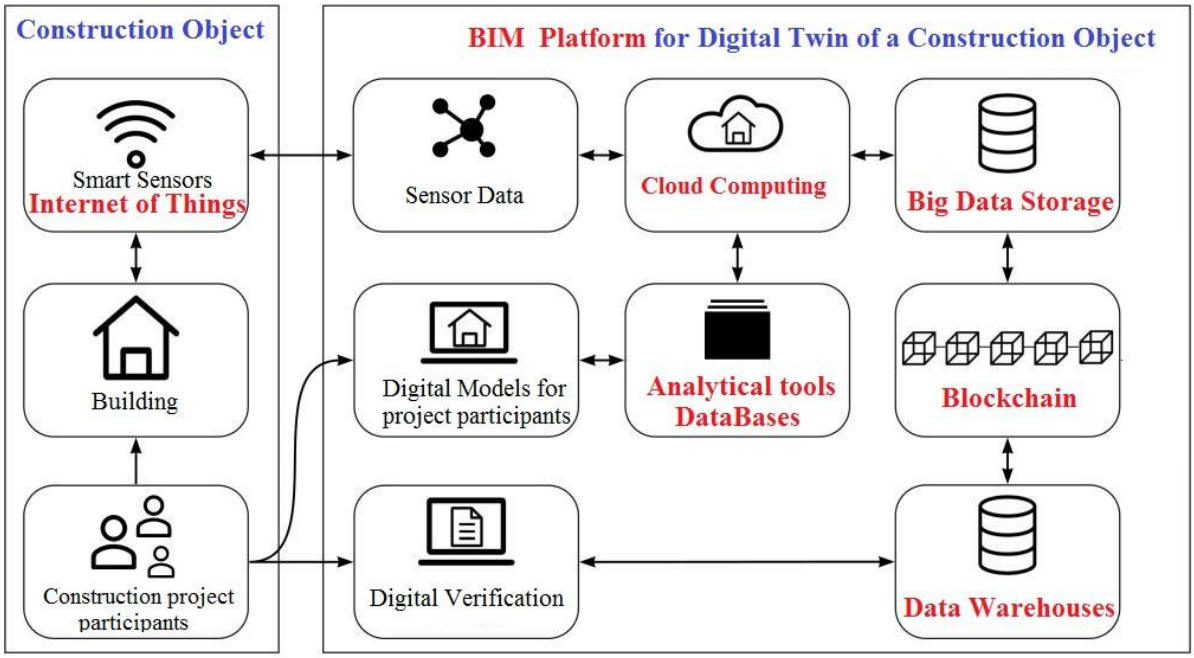


Figure 4: The proposed system architecture based on integration of BIM, IoT, Big Data Storage, Cloud Computing and Blockchain

Digital technologies in any industry lead to the economic feasibility of the transition from the number of automated business processes to their qualitatively new information and communication organization and a change in the production organization system. In recent years, on the basis of network communication tools, complex digital production concepts have been formed, which allow organizing the interactions of production participants on new principles.

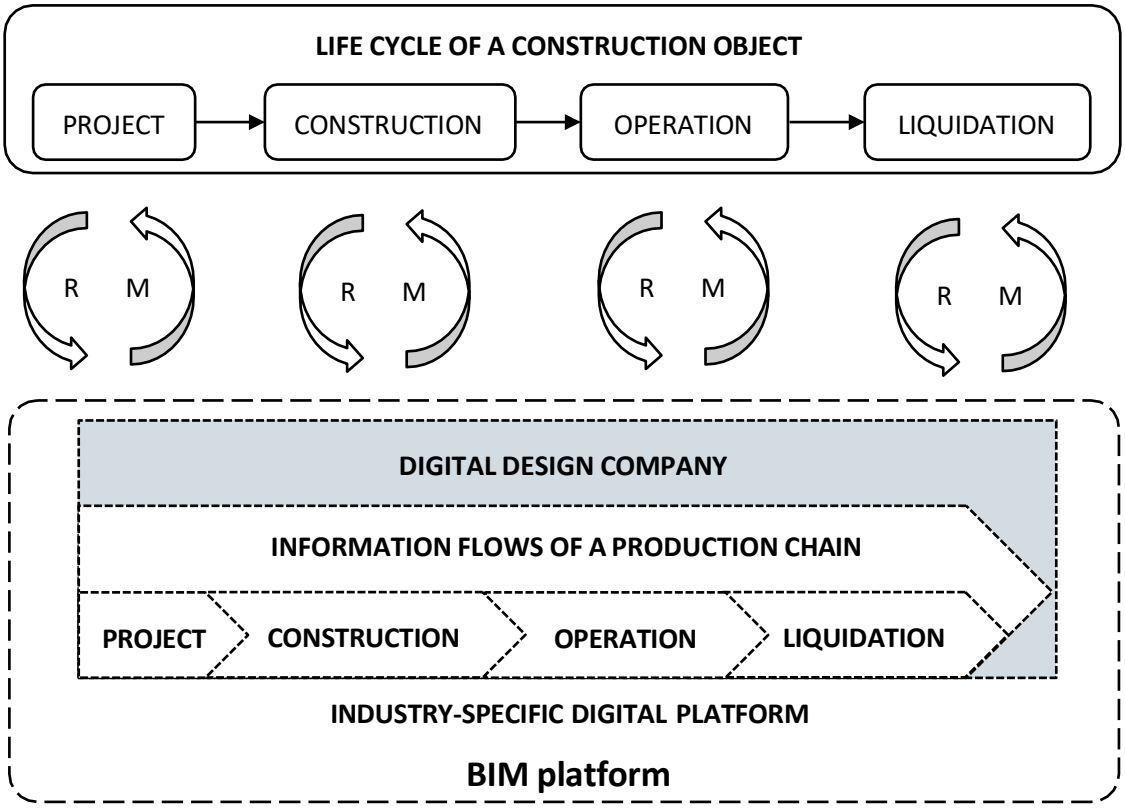
The defining concept of sectoral digitalization in general and the construction industry in particular, is the sectoral digital platform [24]. The platform consolidates all information and communication software tools necessary for solving industry problems, provides specialists and other participants with access to information and professional services for analytics, planning, organization, management, etc. Without a platform, it is impossible to track the full life cycle of a project and correctly reflect it with information flows. The backbone property of a digital platform is its functionality or an ordered set of algorithms for interactions between project participants and production in a single information space. The available interaction functions of the project participants and the corresponding algorithms determine the advantages, disadvantages, effectiveness and level of maturity of the digital platform. Platforms are classified depending on the functionality available. The industrial digital platform for capital construction must have comprehensive functionality that allows it to solve information tasks (access and work with data on the project and

the real estate market), infrastructure tasks (access to digital resources), technological tasks (access to specialized tools and technologies) and corporate tasks (optimization of control processes).

To manage the life cycle of a capital construction object, a management model with a flexible organizational structure is proposed that meets the peculiarities of transformations of successive stages and the composition of participants in the life cycle of a capital construction object is a virtual design enterprise. Fig. 5 shows a model of a project company for managing the life cycle of a construction object.

During the life cycle of an object, a lot of resources are integrated under the project: financial, production, material, intellectual, information, communication, etc. Mobilization of the necessary resources for the needs of the sequential stages of the project can be based on the industry digital BIM platform within the infrastructure and functional services of the virtual project enterprise. The industry digital platform and its tools allow you to quickly organize the attraction of resources and constantly monitor the project. The platform makes it possible to use the resource in the required amount in the required period of time and reduce losses from downtime or resource search. A virtual project enterprise as a management model, along with organizational flexibility, reduces the use of its own resources to the necessary and sufficient minimum. In practice, an own asset in most cases is more expensive than the attracted resource, since it must be maintained in operational condition, even when it is not being serviced. In a virtual engineering enterprise, only those resources are used as its own assets that are required over a long period of the project life cycle. This becomes another factor in increasing the efficiency of the project and its life cycle.

The virtual engineering enterprise operates in real and digital format throughout the entire life cycle of the facility. The information flows of the successive stages of the life cycle are built conceptually as a production chain on a single industry digital platform. All organizational and resource changes are recorded in the digital twin of the project in real time using cloud technologies, big data, the Internet of things and communication technologies for transferring large amounts of information.



R – resource (request ↔ resource mobilization)
M – management (rationale ↔ controlling action)

Figure 5: A model of a digital project company for management of the life cycle of a construction

object

6. Conclusions

The digital transformation of the construction sector is proposed by this research via the integration of four information technologies, each with their own set of advantages and disadvantages. Integrating building information modeling (BIM) with blockchain technology may enhance the efficiency and security of a supply chain, asset management, and construction project. Digital data from dynamic projects is, however, not included in these technologies. Dynamic digital data is provided throughout a construction project's life cycle by integrating IoT and BIM; yet, because to the disparate forms of this data, standardized analytical tools are needed for processing, storing, and sharing Big Data. All project data must be provided digitally in order for the Internet of Things (IoT) and Blockchain to work together, which is why BIM is essential. Accessing digital information about a building project and organizing its usage in the most effective and safe manner is made possible by integrating all four technologies.

So, it's safe to say that information modeling technologies are a very exciting field. The "relevance of BIM technologies" is a hot subject at conventions and conferences of all stripes. Construction companies that are transitioning to information modeling technologies may rely on state preferences to support their use of BIM, since the state is very interested in implementing these technologies in the construction sector. While some of the state's demands on construction organizations may seem insurmountable at the moment, the lessons learned from other nations' experiences indicate that these problems will eventually be solved.

Realization of the critical necessity to reevaluate BIM technology's aims towards life cycle management and long-term economic models of capital building items occurred. Based on these viewpoints, the production idea is encouraging - a digital design firm operating on a unified industry BIM platform, integrating digital resources that match the details of data flows across a construction project's whole lifespan.

As a management model, virtual design enterprise helps to optimize and lower the expenses of current management systems. This management model on the industry BIM platform has the potential to provide the IT groundwork for a newly organized workplace and improved communication between businesses and their workers with further refinement and deployment. Simultaneously, a virtual project enterprise is suggested as a production model and organizational foundation for moving towards full cycle BIM, managing the whole project life cycle, and reengineering the associated information flows.

Lastly, the authors assert that the construction sector may benefit from digital transformation via the use of integrated BIM, Cloud Computing, Internet of Things, Big Data, and Blockchain information technologies.

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