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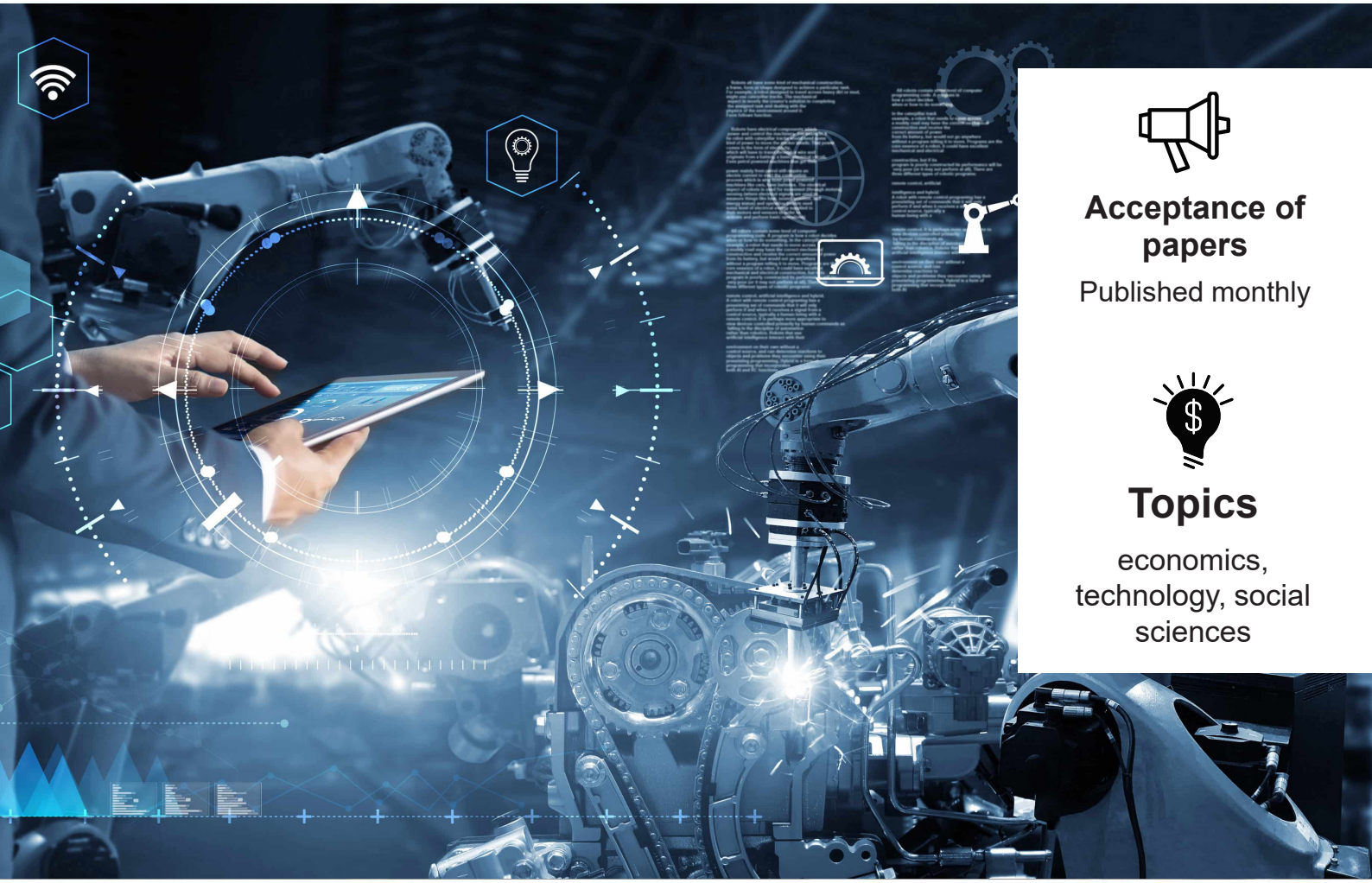

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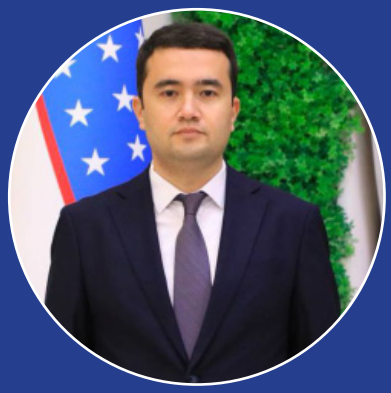



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# BASIC INFORMATION MODEL OF A DIGITAL OBJECT

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**Abstract:** Modern information management methods are based on formal models that make it possible to systematize information about various entities and establish logical relationships between them. This paper addresses the task of developing a formal description of an information object. The concept of a basic description of a digital object is introduced as a set of components including the object's unique identifier, as well as its static and dynamic characteristics. The paper substantiates an approach that makes it possible to analyze the state of an object at different points in time and to construct a model that takes into account the intermediate stages of the object's development.

**Keywords:** information model of a digital object, systematization of information about various entities, general concept of modeling.

**Annotatsiya:** Zamonaviy axborotni boshqarish usullari turli obyektlar haqidagi ma'lumotlarni tizimlashtirish va ular o'rtasida mantiqiy bog'lanishlarni o'rnatishga imkon beruvchi formal modellarga asoslanadi. Ushbu ishda axborot obyektining formal tavsifini ishlab chiqish vazifasi ko'rib chiqilgan. Raqamli obyektning bazaviy tavsifi obyektning noyob identifikatori, shuningdek uning statik va dinamik xususiyatlari majmuasi ko'rinishida kiritilgan. Ishda obyekt holatini turli vaqt oralig'ida tahlil qilish, obyekt rivojlanishining oraliq bosqichlarini hisobga olgan holda model yaratish imkonini beruvchi yondashuv asoslab berilgan.

**Kalit so'zlar:** raqamli obyektning axborot modeli, turli obyektlar haqidagi ma'lumotlarni tizimlashtirish, modellashtirishning umumiy konsepsiyasi.

**Аннотация:** Современные методы управления информации базируются на формальных моделях, которые позволяют систематизировать информацию о различных сущностях и установить между ними логические связи. В работе решается задача разработки формальных описания информационного объекта. Введено понятие базового описания цифрового объекта в виде набора компонент уникального идентификатора объекта, совокупности статических и динамических характеристик объекта. В работе обоснован подход, позволяющий анализировать состояние объекта в различные время, строить модель, учитывающую промежуточные стадии развития объекта.

**Ключевые слова:** информационная модель цифрового объекта, систематизация информации о различных сущностях, общая концепция моделирования.

## INTRODUCTION

The information and communication space consist of a huge amount of weakly structured information [1]. Considering the information space, the following categorization of the presented information can be introduced: textual information, audio information, video information, graphic information.

In general, this categorization covers all information presented on the global Internet. In turn, the information contained in the global network can be attributed to various information objects. By an object, we will understand any entity having a name and a boundary (clear or unclear) with the surrounding environment. It is necessary to clarify that this work considers information objects represented in the virtual Internet environment — a digital object — and separately there is the task of correlating an information object (an image of a physical object) with a real-world object [2]. This task cannot always be solved unambiguously, which is due to the most general principles of the organization of the Internet and the World Wide Web.

As scientific and technical objects, we will consider: publication, patent, scientific and technical report.

The work solves the problem of developing a formal description of an information object [3], capable of:

unifying the representation of data of heterogeneous nature (scientific articles, patents, reports, social profiles, etc.) taking into account their features;

ensuring the connection between static (constant or rarely changing) and dynamic (changing over time) parameters, which is especially relevant for long-term observations and forecasting;

formally defining computable characteristics necessary for analysis (for example, ratings, Hirsch index, cumulative publication metrics, etc.);

flexibly supporting restructuring and expansion of the model with new characteristics and relationships as new requirements and tasks arise;

demonstrating universality: the model should be applicable in various subject areas where it is necessary to store and interpret complex objects, as well as synthesize new information based on existing data.

## REVIEW OF LITERATURE ON THE SUBJECT

In the context of modern digital transformation, the modeling of information objects, systematization of data about digital objects, and analysis of their dynamic characteristics have become important areas of scientific research. Foreign researchers have conducted numerous studies on digital objects, information modeling, and Digital Twin concepts. In particular, Grieves and Vickers developed the Digital Twin concept, which addresses issues related to monitoring and analyzing the state of a physical object through its virtual model in a digital environment. Tao and co-authors investigated the application of Digital Twin technologies in industrial processes, including lifecycle monitoring of objects and the organization of intelligent management. However, these approaches are mainly focused on creating digital replicas of physical objects and do not fully address the problem of formal universal description of information objects.

Local and CIS researchers have also carried out studies in the field of information modeling. In particular, within the framework of Building Information Modeling (BIM) technologies, research has been conducted on the formation of digital models of construction objects, verification of information models, and analysis of attributive data. In addition, there are studies related to the formalization of scientific and technical object data and their systematic storage in databases. However, these studies mainly focus on specific domain objects, while a unified universal information model for digital objects of different nature has not been sufficiently developed.

The uniqueness of this research lies in the proposal of a universal basic information model that formalizes a digital object based on a unique identifier, static characteristics, and dynamic characteristics. Unlike existing studies, this approach makes it possible to describe not only domain-specific objects but also scientific articles, patents, reports, social objects, and other digital information objects within a single unified framework. This creates new opportunities for automated analysis of information objects, tracking their changes over time, and applying them in intelligent analytical systems.

## RESEARCH METHODOLOGY

Modern methods of information management and data analysis are based on formal descriptive models that make it possible to systematize information about various entities and establish logical relationships between them. In the context of intelligent analysis of scientific, technical, and socially significant objects, the consistency of approaches to describing the properties of these objects and the mechanisms of their transformation is of particular importance [4].

The methodology of this study is based on systems, structural, and formal-logical approaches to the analysis of digital information objects. The main objective of the research is to develop a universal basic information model of a digital object that provides a formalized description of its structure, properties, and the dynamics of changes

in its characteristics over time.

During the study, a systems approach was applied, allowing the digital object to be considered as a complex information entity consisting of interconnected components, including identification, static, and dynamic characteristics. This approach ensures a holistic representation of the object and makes it possible to consider its state at different stages of its life cycle.

To structure the characteristics of the object, the formal modeling method was used, aimed at constructing a logically organized information model. Within this method, the digital object is represented as a set of formalized parameters, including a unique object identifier, constant characteristics, and time-varying parameters. This approach makes it possible to unify the description of objects of different nature and ensure the possibility of their subsequent automated analysis.

The study also employed a comparative-analytical method, involving the analysis of existing approaches to information modeling, including the concepts of digital objects, digital twins, and information modeling technologies. This made it possible to identify the limitations of existing solutions and define the requirements for a universal model for representing digital entities.

## ANALYSIS AND RESULTS

A digital information model is a structured set of data describing an object at all stages of its life cycle. In essence, it is a digital analogue of a real object that reflects its current history and its predicted parameters.

Digitalization based on Building Information Modelling (BIM) involves the automation of all stages and procedures throughout the entire life cycle of an object. BIM technology is widely used in the West, where not only 3D modeling, but also 5D, 6D, and even 7D modeling are already practiced.

Let us introduce a categorization of the two main groups of information objects of the global Internet network considered in this work: social objects and scientific-technical objects [5].

The listed groups are closely interconnected, since some social objects are part of scientific and technical information.

Let us introduce a categorization of the social objects considered in this work: person, organization, message in a social network or messenger, state.

All other objects will be considered as special cases of the listed categories.

As scientific and technical objects, we will consider: publication, patent, scientific and technical report.

Each of the digital information objects possesses a certain, previously unknown, set of characteristics. Let us provide examples of characteristics for such a scientific and technical object as an article — authors, abstract, article text, tables, bibliography, etc. This list of characteristics is not final, since solving analytical tasks may require identifying specific characteristics such as formulas, figures, etc.

The values of characteristics are contained in the global network both in aggregated and scattered forms [6].

The number of characteristics of an information object varies and may reach several dozens. Moreover, objects of the same type may possess all defined characteristics, or may not possess them.

Let us introduce the concept of the basic description of a digital object in the form of the following set of components:

$$(\text{Obj} = \langle \text{ID,S,D} \rangle, \#(1))$$

where ID – is the unique identifier of the object; S – is the set of static characteristics; D – is the set of dynamic characteristics (changing over time or under external influence).

**The unique identifier** (*ID*) serves for the unambiguous identification of objects when solving analytical tasks and for minimizing the risks of duplication or ambiguous interpretation. This characteristic is systemic and is assigned during the first registration of the object in the information repository [5].

**Static characteristics** are characteristics whose values either do not change throughout the entire period of the object's existence or change extremely rarely. Examples:

Full name of the author of a scientific publication;

Primary state registration number of an organization;

Unique identifier (for example, the DOI of an article).

From a formal point of view, the set of static characteristics can be defined as:

$$S = \{(s_1, \tau\_1), (s_2, \tau_2) \ldots, (s_k, \tau_k)\}, \quad (2)$$

Where $s_i$ – is the name of the *i- th* static characteristic (for example, author, organization name), $\tau_i$ – is the type of this characteristic (string, number, etc.), *i=1, 2..., k.*

The classification of static characteristics by data types makes it possible to process them correctly at the stages of

aggregation and analysis (different processing methods are applied for text fields and numerical fields).

**Dynamic characteristics** are characteristics whose values may change over time or under the influence of external factors.

In analytical research, it is sometimes necessary to store the history of changes and have the ability to return to the state of an object at a specific moment (or on a specific date). Examples:

number of message views;

number of citations;

number of employees in an organization;

Within the framework of intelligent analysis, such variability is considered as a function of time [6].

$$D = \{(d_1(t_1), t_1, \tau_1), (d_2(t_2), t_2, \tau_2), \ldots, (d_l(t_l), t_l, \tau_l)\}, \quad (3)$$

Where $d_j(t_j)$ – is the value of the $j$- th dynamic characteristic at time $tj$, $tj$ – is the time value, $\tau_j$ – is the type of this characteristic (string, number), $j = 1,2, \ldots, l$.

For example, $(d_{cit}(t_1), t_1, \tau_1)$ – represents the number of citations of an article at time $t_1$, where $\tau_1$ – is a numerical field.

This approach makes it possible to analyze the states of an object at different times $t$ and compare them, as well as to design models that take into account intermediate stages of the object's development.

Solving analytical tasks is often impossible based only on static and dynamic characteristics, which leads to the need to enrich the model with additional characteristics.

## CONCLUSIONS AND SUGGESTIONS

As a result of the conducted research, the problem of formalized representation of digital information objects in the context of the rapid growth of digital data volumes and the development of intelligent information systems was examined. The analysis showed that existing approaches to modeling information objects, including digital twins, BIM models, and specialized information systems, are in most cases focused on specific application domains and do not provide a universal approach to describing digital entities of different nature. In this regard, a basic information model of a digital object was proposed, based on the use of a unique identifier, static characteristics, and dynamic characteristics, allowing the formalization of the object structure, consideration of its changes over time, and ensuring a systematic representation of information.

The developed model has universality and can be applied to describe various types of digital objects, including scientific publications, patents, technical reports, social objects, and other information entities. The practical significance of the research lies in creating a conceptual foundation for the automated storage, processing, analysis, and intelligent interpretation of digital information. As recommendations, further development of the model is proposed through the integration of artificial intelligence methods, machine learning, and big data technologies for the automatic extraction and analysis of digital object characteristics. It is also advisable to conduct practical testing of the model in real information systems to evaluate its efficiency, scalability, and adaptability across different application domains.

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