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The reflection of managerial control actions in the digital twin of the organization

Отражение управляющих воздействий руководителей в цифровом двойнике организации

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Abstract

The work carried out earlier allows us to assert that a digital twin of an organization can be created on the basis of a comprehensive agent-based mathematical model of a social system functioning in an active environment. Such a digital twin, consisting of a set of databases for recording initial data and calculated values of system parameters, as well as data collection and processing modules, allows you to automate the functions of analyzing the activities and the state of the organization to determine systemic problems, the causes of the results of activities, as well as the calculation of control actions and determining the effect of the control actions of the head.

The purpose of this work is to determine the parameters of the control action that need to be recorded in the digital twin of the organization in order, using a simulation model, to calculate the effect of the impact, the dynamics of the social system in the socio-economic space.

Keywords: digital twin of an organization, digital twin of a social system, comprehensive mathematical model of a social system, active

Аннотация

Проведённая ранее работа позволяет утверждать, что может быть создан цифровой двойник организации на основе сформированной комплексной агентной математической модели социальной системы, функционирующей в активной среде. Такой цифровой двойник, состоящий из совокупности баз данных для фиксации исходных данных и расчётных значений параметров системы, а также модулей сбора и обработки данных, позволяет автоматизировать функции анализа деятельности и состояния организации для определения системных проблем, причин полученных результатов деятельности, а также расчёт управляющих воздействий и определение эффекта от управляющих воздействий руководителя.

Цель работы – определить параметры управляющего воздействия, которые необходимо зафиксировать в цифровом двойнике организации, чтобы, используя имитационную модель, рассчитать эффект от воздействия, динамику социальной системы в социально-экономическом пространстве.

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system, activeness, organization management, controlling influence.

Ключевые слова: цифровой двойник организации; цифровой двойник социальной системы; комплексная математическая модель социальной системы; активная система; активность; управление организацией; управляющее воздействие.

Introduction

The term "digital twin" (DT) is often used to refer to a computer model simulating the behavior of a real object. GOST R 57700.37-2021 defines a DT as "a system consisting of a digital model and bidirectional information links with the product ... or its ... parts"[6]. In the context of our objective, it is important to note that such a model contains information about the values of phase variables at specific points in time and a module that calculates the system's dynamics based on this data. Strictly speaking, the DT of an object is a data set (phase variable values) that, using a simulation model, allows for the calculation of the object's dynamics and changes in its properties (i.e., the nature of the object's interaction with the environment). Applied to an organization, this involves simulating the movement of a social system in the socio-economic space (SES), implying the presence of data about the object and its operating environment.

Agent-based models are increasingly being utilized for the modeling of social systems. The development of such models is outlined in the Fundamental Scientific Research Program until 2030, approved by the Government of the Russian Federation[7]. To apply these models practically, there is a need for software and hardware complexes that implement the model.

Considering the above and the goals of digitizing the economy and society, the digital twin (DT) of the organization should ensure the recording and processing of data that allow tracking changes in the organization during the modeling of perturbations, managerial actions, and other influences. The data and dependencies should consider all significant cause-and-effect relationships, enabling the simulation of the organization's behavior in the market environment. To achieve this, the DT should allow:

- Recording the organization's state: capture the organization's state and the environment in the form of phase variable values.
- Recording changes in the organization's state: document changes in the organization's state (values of phase variables) in response to any events, altered circumstances, or agent actions.
- Calculating changes in the social system: calculate changes in the state and properties of the social system when modifying the values of phase variables.

The technical implementation of the digital twin (DT) involves a complex of databases and a module (or modules) for processing real-time values of phase variables to model activeness (processes), the state of the social system, calculate its behavior, and assess the consequences of management subjects' actions and the environment.

The aim of the study is to determine the parameters of managerial impacts (MI) by management subjects that need to be recorded in the DT databases. This information is crucial for assessing the effects resulting from the implementation of MI.

Literature review

In the literature, there is a lack of comprehensive materials addressing the formalization and calculation of MI in social systems. Works related to MI in technical systems (see, for example, (Tyunkov & Bocherova, 2012)) provide strict dependencies, describe parameters, and the mechanism of MI. In the context of social systems, predominantly, individual processes and some influencing factors on the outcome are described. There are examples of practical implementation, but often these examples and processes are discussed

[6] GOST R 57700.37–2021 Computer Models and Simulation: Digital Twins of Products. General Provisions. – Moscow: Russian Institute of Standardization, 2021.
[7] Program of Fundamental Scientific Research in the Russian Federation for the Long Term (2021-2030). Approved by the decree of the Government of the Russian Federation dated 31.12.2020 No3684-r / https://docs.cntd.ru/document/573319222?marker=64U0IK

without sufficient reflection on implementation conditions, and the influencing factors are considered in an abstract manner, without fully disclosing the mechanism of influence.

The management system implies the presence of a control device (or a management subject in a social system), a managed object, the impact on which alters its functioning, MI, and the result. There should also be a controlling device or organ that determines the trajectory of movement, final and intermediate goals, etc.

When performing a management act, the subject influences the object to bring it into a new desired state. In management, methods are divided into economic (material incentives), organizational and directive (orders, directives, etc.), and socio-psychological (suggestion, imitation, etc.) (Fundamentals of management (n.d.)). It is worth noting the inaccuracy of the traditional definition: 'management method is a set of ways and means of influencing the managing subject on the managed object to achieve ... goals' (Fundamentals of management (n.d.)) – the right and left parts do not correspond to each other: the right part can be recognized as a definition of the method of influence (although it is vague), but not every influence will be management, so it is incorrect to equate the management method with 'a set of ways and means of influencing...'. The management method is a way of management. In general, there are only three main ones – without feedback, with feedback on perturbing influence, and with feedback on the result – and their combinations.

Universal methodology for calculating MI in management has not emerged. This is often explained by the fact that the impact is realized in a specific situation involving specific individuals under different conditions. However, the main reason is the lack of a strict theoretical foundation and the associated ability to reason abstractly. The tasks of automating activeness require the calculation and quantitative assessment of all influencing factors and unambiguous relationships between variables.

One of the factors is social institutions. Social institutions are often understood as a "stable complex of formal and informal rules, stereotypes, norms, attitudes, controlling various areas of society's activity and individual personality, as well as organizing the system of roles and statuses of a person" (Danilova, 2009, p. 14). While agreeing that formal and informal rules, stereotypes, etc., are social institutions, a stricter interpretation is considered here – an institution is information about actions and consequences obtained by an individual through reading regulatory documents or observing the behavior of agents. Consequences are the sum of resources gained (incentives) and resources lost (constraints) because of an action. Institutions influence the behavior of an agent (the probability of the agent performing actions) but do not "control" them.

Nevertheless, it is worth noting the existence of works attempting to define approaches to the calculation of MI. In (Verzilin & Shahygin, 2011), the authors note: "When studying the processes of managing a social system, modeling tools must fully implement the system approach principle and represent a set of formalized models ... of various scales and purposes, taking into account all the most important factors ..., providing the development of well-founded and timely recommendations when making decisions ..." (Verzilin & Shanygin, 2011, p. 83). Here, a hierarchical system is considered, requiring decisions on management tasks through "coordination selection." This refers to management where the upper-level element controls the lower-level elements through actions that influence the development of decisions in the governing bodies of these elements (Verzilin & Shahygin, 2011, p. 81).

Note that specifically, the digital twin (DT) of an organization can serve as a tool for calculating MI in the decision-making process.

Works related to modeling MI often do not consider the calculation of impact but rather describe certain actions in a specific situation. For instance, in (Alidodov A., & Averchenkov , 2022), the BPMN specification is used to describe the management process in the system 'Tajik students admitted to Russian universities' (Alidodov A., & Averchenkov, 2022, p. 87). While useful as an experiential description, it does not reveal the full set of factors influencing the decision, nor does it provide calculation algorithms, etc.

In some works, the focus is on informational impact and human perception of information. For example, in (Liberman, 2023), the calculation of the strength of informational impact is oriented towards computer application for measurement and recording. Psychology and sociology also pay attention to how humans perceive different types of information, including hidden MI. However, it's important to note that there is often an unjustified division of essentially the same influence based on the goals of the management subject: if it's explicit and 'well-intentioned,' it's considered management; if implicit and/or 'pursuing one's own goal,' it's considered manipulation. For instance, in (Sheynov, 2006), a technology of hidden control is defined, consisting of stages: '1) collecting information about the addressee; 2) detecting targets of influence and bait; 3) attraction; 4) compelling the addressee to act; 5) gain for the initiator of the impact ' (Sheynov, 2006, p. 56). There is a somewhat negative connotation with terms like 'bait,' 'compelling'... However, viewed impartially, any influence involves informational impact, and the distinctions between these influences are based on the goals of the management subject.

From the perspective of information perception, psychology and sociology focus on the alphabet people use. In (Kara-Murza, 2017), it's demonstrated how different symbolic systems affect perception, noting that words can suggest something to a person, influencing their behavior (Kara-Murza, 2017, p. 141). A.V. Savchenko's work (Savchenko, 2008) explores latent control – covert purposeful impact where the subject of activity (management object) consciously accepts and implements decisions predetermined by the subject of latent control. Acting rationally and reasonably, individuals or groups subjected to latent impact, due to distorted information, lack of knowledge, or biased event assessment, act in the interests of the subject of latent control (Savchenko, 2008, p. 10-11). The rationale for modeling MI is emphasized. For this purpose, a DT can be used, including an imitation model of the organization.

In some works (see, for example, (Rogachev et al., 2019)), MI is presented as streams of financial resources. However, it should be noted that such representation can only be used for certain large-scale management tasks, as the calculation error becomes significant due to unjustified abstraction from all other factors influencing the behavior of the social system.

Methodology

We utilize a mathematical agent-based simulation model of a social system, which defines the data structure required for calculating the system's dynamics and enables the computation of the social system's dynamics in the SES (Samosudov, 2021; Samosudov, 2019; Samosudov, 2019a; Samosudov, 2021a; Samosudov, 2022; Samosudov & Bagrin, 2022; Bagrin & Matyash, 2022).

The model is based on a resource-functional approach to the analysis of social systems. This approach assumes an understanding of social systems of various purposes and scales as functional systems that require a specific resource base, including material, informational, intellectual, social, spatial, and human time resources. A key condition is the ability to formulate functions correctly and consider resources in the utmost specificity (Samosudov, 2019), avoiding unnecessary generalizations. The developed methodological materials allow for precise calculation of the necessary resource base for implementing specific functions.

The creation of the model was preceded by the following fundamental scientific achievements relevant to this task (Samosudov, 2012; Samosudov, 2019; Samosudov, 2019a; Samosudov, 2021; Samosudov, 2021a; Samosudov, 2022; Samosudov & Bagrin, 2022):

- Development of a rigorous theoretical framework describing the dynamics of the social system in the SES and defining the conditions for functional stability.
- Development of a method for quantitative assessment and consideration of all types of resources, including intellectual, informational, social, organizational, etc.
- Development of a method for formalizing processes (activities) through the documentation of resource transformations using multidimensional matrices.
- Development of a method for formalizing the content of documents and informal rules (social institutions) and their influence on the likelihood of individuals performing certain actions.
- Development of a method for accounting for the systemic activeness of agents.
- Development of a method for reflecting the influence of the environment on agent behavior through the calculation of gradients at the point of SES.
- Identification of invariants and variable quantities characterizing the process of agent interaction.

This allowed defining a data structure for capturing the state of the social system in the digital twin (DT) database for dynamic system calculations. The model implements a Markov process, so modeling a specific organization does not require a significant amount of data on past activities. It is sufficient to describe the current state of the organization and the environment to calculate its dynamics.

The work on the project "Digital Twin of a Social System: Substantiation of Content and Application Possibilities for Management" (Russian Science Foundation (n.d.)) demonstrated the possibility of describing the state of any social system with a structurally identical set of phase variables. While the values of variables may change, the structure remains the same. It also confirmed the feasibility of implementing a digital twin of a social system and identified approaches to using the digital twin in the management system.

Results and discussions

The activity of a social system is inherently tied to its constant change and occurs in a continually changing environment. Social systems are inherently dynamic and active systems, operating in a dynamic and active environment[8]. Due to the system's activeness, the environment reacts to its presence by redistributing resource flows. If the system's impact is adequate, such redistribution will lead to the formation of resource flows entering the system. However, the system's activeness arises from the activeness of agents shaping the system (not only founders and organizers but also other participants in corporate relationships).

Due to the absence of stationary states for both the system and the environment, for the system to function and maintain this capability in the future, management of the system's movement in the environment is necessary – a change in its state over time. While the state will naturally change, relying on random processes and the natural course of events is not advisable in an active and, arguably, aggressive environment where economic agents seek to redirect resource flows in their favor. It is necessary to manage the change in the system over time to ensure the necessary incoming resource flow from the environment for the social system's existence.

MI should lead to a change in the system's trajectory towards a target state. Its consequence is the alteration of the values of phase variables (system parameters), leading to a change in the state and properties of the system.

In the context of social systems, we might be interested in the functional stability of the system (the ability to maintain functionality in changing conditions); the attractiveness of the system to certain agents and, if necessary, unattractiveness to others (e.g., raiders, dishonest employees, clients, etc.); the ability to adapt to operating conditions (directly related to manageability); as well as other similar properties.

The change in the system is determined by the actions of interacting agents – if their actions lead to a change in the system's resource base, functional concentration of resources, then the properties of the system change.

Let's introduce the theorem: to correct the movement of a social system in a SES, it is necessary to appropriately change the behavior of agents by transmitting flows of messages and resources to them.

Let Ω be a system moving in the SES Θ. A functional social system can be considered as a subset of the SES, with a sufficient concentration of resources and structured activeness by agents to maintain the functionality of the system ($\Omega \subset \Theta$). It is precisely the combination of resources in an active form that provides the possibility of implementing a function. However, for the activities of social systems, resources inseparable from humans (intellectual resources, some social resources, etc.) are also necessary, requiring structured activeness of agents.

The combination of the states of the system and the environment determines the system's situation, characterized by incoming resource flows from agents interacting with it (resources should be considered broadly – not only financial but also other resources that are significant).

[8] That is, at any given moment in time, there is at least one parameter of the system and the environment, the rate of change of which is not equal to zero.

If the incoming resource flows (IRF) are sufficient, in the SES corresponding to the considered social system, a certain spatiotemporal concentration of resources in an active form will emerge, enabling the realization of necessary functions, and the system will be capable of functioning[9].

The movement of the social system Ω in the SES is characterized by the rate of change of the system, dΩ/dt, and its trajectory is described by the following equation[10]

$$\Omega(t) = \Omega(t_0) + \int_{t_0}^{t} \frac{d\Omega}{dt} dt \qquad (1)$$

The management subject's task is to minimize the deviation of the actual trajectory from the calculated trajectory of the system's movement towards a specific target state.

The target state is the condition of the system that ensures functioning results aligned with the expectations (desires) of key participants in corporate relationships. This could involve the system's ability to generate sufficient IRF or other properties such as functional sustainability, the capability to produce the required products in the desired quantity, attractiveness to specific agents, etc.

The rate of change of the system depends on the flows of resources $\hat{R}_j^k(t)$ and messages $\widehat{M}_j^k(t)$, emanating from the points of the SES. If the *k*-th point of the SEP (receiver) is within the region corresponding to the system Ω, the system changes – the resource base changes, the information received by agents changes, and their activeness changes. As a result, the properties of the system change.

In other words, the system undergoes movement, more or less aligned with the management task. If the Inflowing Resource Streams correspond to what is necessary for the adaptation of system Ω to changing conditions, the trajectory of movement will change accordingly. If not, the mismatch between the system and the environment will increase.

The resource flow $\check{R}_\Omega^\Theta$ entering the system Ω from the SES Θ is determined by the actions of SES agents – by performing actions o_x, the *j*-th agent transforms the resource base under its control[11] $R_j(t)$ into $R_j'(t)$ and creates outgoing flows of resources $\hat{R}_j^k(t)$ and messages $\widehat{M}_j^k(t)$ from the *j*-th point of the SES to the *k-th* point of the SES:

$$R_j(t) \overset{o_x}{\to} \{R_j'(t), \hat{R}_j^k(t), \widehat{M}_j^k(t)\} \qquad (2)$$

Note: In general, the possibility of zero flows of messages and resources emanating from point j of the SES should be taken into account, but the transformation of the resource base always occurs.

However, as shown earlier in (Samosudov, 2021a; Samosudov, 2022), the set of actions of the *j*-th agent$O_j(t)$, performed by him at time *t*, is determined by the value of his behavior vector (BV) $B_j(t)$ – its components equal to 1 are elements of this set:

$$O_j(t) = B_j(t) | p(o_k) = 1 \qquad (3)$$

As a result of the agent's interpretation in accordance with the alphabet $\mathcal{M}_j$ of the received streams of messages $\breve{M}_j^k(t)$ and resources $\check{R}_j^k(t)$ the BV of the agent changes under the influence of the received information $\check{I}_j(t)$ – a set of stimuli, constraints, and the probability of the consequences of certain actions occurring, which in the model is taken into account by means of a matrix of size *k*×(2[*n*+*m*]+1):

[9] That is, at any given moment in time, there is at least one parameter of the system and the environment, the rate of change of which is not equal to zero.
[10] The system's state is described by a state vector, each element of which is the value of a phase variable (system parameter). However, for the sake of simplicity, we do not detail the change in state by individual parameters here.
[11] For simplicity, we do not consider here that the transformation of the resource base takes some time, and we write $R_j(t) \overset{o_x}{\to} \{R_j'(t), \hat{R}_j^k(t), \widehat{M}_j^k(t)\}$, as if assuming instant transformation.

$$\begin{Bmatrix} \check{R}_j^k(t) \\ \check{M}_j^k(t) \end{Bmatrix} \xrightarrow{\mathcal{M}_j} \check{I}_j(t)$$

$$\check{I}_j = \begin{pmatrix} o_1 & s_1^1 & \cdots & s_n^1 & p(s_1^1) & \cdots & p(s_n^1) & l_1^1 & \cdots & l_m^1 & p(l_1^1) & \cdots & p(l_m^1) \\ \vdots & & \vdots & & & \vdots & & & \vdots & & & \vdots & \\ o_x & s_1^k & \cdots & s_n^k & p(s_1^k) & \cdots & p(s_n^k) & l_1^k & \cdots & l_m^k & p(l_1^k) & \cdots & p(l_m^k) \end{pmatrix} \quad (4)$$

o_x	–	x-e conditional action;
s_n^x	–	stimuli for action o_x (resources of type n obtained when performing the action);
l_m^x	–	constraints for action o_x (resources lost when performing the action of type m);
$p(s_n^x)$, $p(l_m^x)$	–	probability of obtaining resources of type n and losing resources of type m when performing action o_x.

Under the influence of the received information, there arises a divergence of the component of the potential that corresponds to the action o_x:

$$divB_j^x\left(\check{I}_j(t)\right) = \left(\frac{\partial B_j}{\partial s_1(o_x)} + \cdots + \frac{\partial B_j}{\partial s_m(o_x)} + \frac{\partial B_j}{\partial l_1(o_x)} + \cdots + \frac{\partial B_j}{\partial l_n(o_x)} + \frac{\partial B_j}{\partial s_1(\neg o_x)} + \cdots + \frac{\partial B_j}{\partial s_m(\neg o_x)} + \frac{\partial B_j}{\partial l_1(\neg o_x)} + \cdots + \frac{\partial B_j}{\partial l_n(\neg o_x)}\right) \quad (5)$$

The BV of an agent at time t is determined as follows:

$$B_j(t) = B_j(t_0) + \left(\int_{t_0}^{t} divB_j^1\big(\check{I}_j(t)\big)dt, \int_{t_0}^{t} divB_j^2\big(\check{I}_j(t)\big)dt, \quad \cdots, \quad \int_{t_0}^{t} divB_j^x\big(\check{I}_j(t)\big)dt\right) \quad (6)$$

Thus, considering (2), the change in the behavior of agents in the social system Θ alters the outgoing flows of resources $\hat{R}_j^k(t)$ and messages $\widehat{M}_j^k(t)$, from them, thereby changing the state of the system evolving in the SES.

The theorem is proven.

Considering the foregoing, MI is an influence on agents that alters their resource flows, leading to changes in system parameters to adapt the system to a changing environment[12].

In a social system, the following entities exist, determining information that influences the behavior of agents:

- Message flows from one agent to another (or from the organization to agents) – they are interpreted by agents, and in their subjective subspace, subjective assessments of stimuli and constraints related to actions arise.
- Resource flows are also interpreted by agents as information influencing behavior – signals that define subjective assessments of the probability of gaining or losing benefits from interaction in SES, and the existing (accumulated) resource base of the agent affects the subjective assessment of the value of the proposed benefits.
- Institutional environment – formal and informal rules transmitting information about stimuli and constraints associated with actions.

It is important to note that for changing the probability of an agent performing actions, the subjective assessments that arise due to the interpretation of received messages and resources are crucial. Information (a variable entity) between agents is not transmitted; messages and resources (invariant entities,

[12] This should not be regarded as a strict definition of MI, rather as additional information specifying the peculiarities of MI for the tasks of managing social systems.

independent of the SES point in which they are considered) are transmitted. These are interpreted on the receiving end based on the agent's alphabet, considering the resources available and needed by the agent.

In general, in the management process, the subject needs to ensure that, considering the influence of the environment and the subject of management, the BV of the target agent provides the transmission of the necessary resources and messages to the system. Since the influence of the environment and individual subjects on the agent is formalized by calculating the gradient at the SES point corresponding to the agent, this condition can be expressed as follows:

$$grad\{\breve{R}_j^{\Theta}(t), \breve{M}_j^{\Theta}(t)\}: B_j(t) \geq B_{j\,needed}(t) \quad (7)$$

In light of the above, let's consider some "typical" actions of the leader to manage the organization (Table 1).

Table 1.
Comparing the actions of the leader with the content in accordance with the discussed concept.

Manager's actions	Contents
Approval by the governing body of a document regulating activities (regulation, provision, etc.)	The change in the institutional environment of the company, as a result, affects the utility functions of agents and their future activeness: • Prescribed actions are determined – actions that need to be performed in specific situations. • Stimuli and constraints associated with the performance of such actions are identified. $H_{\Omega}(t_1) = H_{\Omega}(t) + H_{document}$ Having read the document, the agent obtains information about the stimuli and constraints specified in the document: $\breve{M}_j^{\Omega}(H_{document.}) \xrightarrow{\mathcal{M}_j} \breve{I}_j \to \Delta B_j = \left(\int_{t_0}^{t} divB_j^1(\breve{I}_j(t))dt, \cdots, \int_{t_0}^{t} divB_j^k(\breve{I}_j(t))dt\right)$ Another way to obtain this information is by observing the actions of agents whose behavior has changed as a result of reading the document. Changes in the institutional environment can also alter resource flows, which may affect agents' subjective assessments and their behavior.
Order (oral or written)	Information about incentives and constraints associated with specific actions, and a flow of resources towards particular participants. This also leads to a change in the institutional environment – the formation of formal social institutions in the case of a written order.
Official conversation between a leader and a subordinate	Targeted direct or indirect (depending on the form and signals) communication about the possibility of taking certain actions and gaining certain benefits. Properly calculated signals will appropriately modify the agents' activeness.
Informal conversation between the leader and subordinate(s)	Informing specific agents, transmitting signals that influence behavior, as a result of interpreting which agents will receive information about necessary actions, incentives, and constraints associated with them. Subjective assessments of expected and desired benefits are formed, and as a result, their activeness changes, leading to the emergence of the necessary outgoing flows of messages and resources if the leader has calculated everything correctly.
A meeting or assembly with subordinates organized by a leader	Informing a group of participants (information flow towards the group of participants). During a meeting or assembly, subordinates receive information about necessary actions, stimuli, and constraints associated with them. Informational resources that facilitate work and consequently reduce the significance of constraints (resources lost by a person in the process of activity) related to task execution can also be conveyed.

Besides the impacts listed in the table, tasks, advice, recommendations, instructions, etc., can be considered. However, essentially, they do not differ from the ones discussed.

To reflect (record) the MI in the DT of the organization, it is necessary to record the following information in the database:

- Identifier of the Impact – a unique code for the impact. It is advisable for the code to reflect the type of impact and possibly the functional direction, but the main requirement is uniqueness.
- Subject of management creating the impact (active agent).
- Agent or agents for whose behavior the impact is intended.
- Content of the message implementing the impact:
- Transmitted signals;
- Translated meaning – a combination of actions, stimuli, constraints, and probabilities of consequences that the agent will "see" when interpreting the impact in accordance with (4).
- Parameters related to the selected channel and method of message transmission:
- Probability of the agent receiving a message transmitted through the channel, or better yet, the distribution of this probability over time if possible. For example, the approved document may be read[13] by the agent with a low probability within the first day of its validity, with a slightly higher probability within a week, and with a high probability within a month. However, the distribution of probability can be reversed – for example, in messengers, the likelihood that the agent will see the message may decrease over time. An option is to fix the time of guaranteed acquaintance with the transmitted message and calculate the effect for the worst-case scenario, but this may reduce the number of possible actions for the manager.
- Information background of receiving the message by the agent – against the background of which messages the agent will interpret the message.

From the perspective of organizing the activities of a social system, it is advisable to record additional accompanying information – the purpose of this impact (i.e., the expected change in agent behavior); the result of the agents' functioning with changed BV (system effect). However, this is more needed for organizing activities, subsequent analysis, etc. For the operation of the DT, this is additional information. The DT's computational block will process this information and calculate the effect of the MI:

- Using the agent's alphabet[14] $\mathcal{M}_j$ the information that the agent will receive as a result of the impact is calculated.
- In accordance with (5), the divergence of the agent's BV is calculated, taking into account information about the agent's existing resources and needs, as well as considering the gradient of the environmental impact at this point in the SES.
- Based on the calculation of the divergence of the agent's utility function, its resulting utility function is determined in accordance with (6).

Based on the value of MI, it is determined whether the agent will perform the actions necessary to generate the required message and resource flows in accordance with (3).

For this, accordingly, the parameters of the agents receiving the message implementing MI must be recorded in the DT:

- Agent identifier[15].
- The agent's BV in the context of actions related to obtaining information. This includes determining the probability of the agent receiving information[16] through the communication channels used for the impact.
- Alphabet of the agent.
- The resources available to the agent and its needs.

In addition to information about the agent, to calculate MI in the DT, information about the environment in which interaction occurs, more precisely, about the impact that the environment has on the agent (the gradient of the environmental impact at the point of SES corresponding to the agent) must be recorded.

[13] The receipt of a document should be taken into account based on the actual reading, not just its delivery through the transmission channel.
[14] In a simple implementation, the alphabet is a table that corresponds signals to a set of stimuli and constraints related to the action that the agent will "see" when interpreting the message.
[15] In general, the model used allows calculating dynamics at any level of detail, down to individual agents. However, it is often appropriate to detail it to the level of subsets of agents with similar characteristics.
The ability to use the same approach for calculations at any level of detail is a fundamental feature of the employed model.
[16] Notice: obtaining information, not messages. Obtaining information implies the agent's familiarity with the content of the message.

This can be calculated through modeling the behavior of agents or, if appropriate to the task conditions, obtained through expert assessments.

Conclusion

The ability to mathematically model the dynamics of social systems in SES, creating a DT for an organization, enables solving a wide range of applied and scientific tasks.

For practical applications, it opens the possibility to calculate the MI of leaders, significantly increasing the efficiency of organizational work. Traditional decision-making often proves inadequate to the situation, leading to resource losses and reduced efficiency. This approach also transforms the organization of marketing research, allowing for precise calculations of agent impact and capturing results, providing much more information about the market using significantly smaller data volumes. For many small and medium-sized companies, traditional methods based on processing extensive customer data are not feasible.

The DT of a social system can be a powerful tool for fundamental research in social sciences.

The model underlying the DT allows representing research results from various fields in a unified format. The work conducted demonstrates that most observed phenomena in social systems (if not all) can be described using the variables used in the model. Essentially, a model of a social system (similar to a "standard model" in physics) can be created, enabling the formulation of hypotheses and the calculation of experiments. This addresses the methodological problem of social sciences, as traditional methods relying on statistical processing of observational results provide sufficient data only with the repeatability of experimental conditions, which is practically impossible in social systems.

The presence of a "standard model of a social system" creates the possibility of coordinating research efforts among different groups and contributes to the development of a theory and model anticipated in the Program of Fundamental Scientific Research until 2030, approved by the Government of the Russian Federation, as one of the expected promising results of scientific activity.

In this work, we demonstrate the feasibility of recording a leader's decisions in the DT of an organization and calculating the effect of implementing such a decision, which is one step towards creating a fully-fledged digital twin of an organization.

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