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MULTI-AGENT MODEL OF THE DISTRIBUTION CHANNELS MANAGEMENT SYSTEM OF AGRO-INDUSTRIAL ENTERPRISES

ABSTRACT

The purpose of this scientific article is to develop a multi-agent model of the distribution channel management system of agro-industrial enterprises in order to identify promising directions for the development of sales policy based on the use of information and communication methods.

To achieve this purpose, the research was conducted on the dialectical method of cognition, the conceptual provisions set forth in the works of domestic and foreign scientists on the distribution channel management of enterprises. To accomplish the assigned tasks, the following basic research methods were used: abstract-logical, abstraction, and concretization, a systematic approach, observation, and an expert evaluation method. The methodical basis of the research was general and special methods, namely: system analysis; economic and mathematical methods, tabular and graphical methods, methods of comparison and grouping, and economic and mathematical modeling in order to develop a multi-agent model of the distribution channel management system of agro-industrial enterprises.

It has been established that the growing need for the development of an effective information system of the distribution channel management of agro-industrial enterprises, increasing the heterogeneity of the constituent elements and the number of parameters of the distribution system requires expanding the range of methodical approaches to the distribution channel management in the direction of modeling the distribution channel management system of enterprises. In particular, this is fundamental in solving the problems of organizing and operational and technical management of the transport distribution network.

At the same time, it is impossible to identify promising directions for the development of sales policy using information and communication methods based on new technologies without the modernization of the existing management system (MS) by developing an information management system, which in the future will enable the realization of all potential opportunities for effective and operational transport network based on packet technologies.

Thus, in connection with a significant change in modern information and communication technologies, a change in the processes of functioning of the elements of the distribution channel management system of agro-industrial enterprises and their interaction, a change in the monitoring mechanisms of the functioning of the system elements, it becomes necessary to develop a new architecture of the management information system of distribution channels (MIS of DC) in order to increase the level of competitive advantages of an enterprise for the long term.

Keywords: agro-industrial enterprise, sales channel management system, management information system, multi-agent system of management, sales management, multi-agent technologies

JEL Classification: Q10, O24, O31, O33

INTRODUCTION

Sales management plays a huge role in any socioeconomic formation. In a market economy, there are significant differences in the goals, functions and methods of management, the degree of responsibility and independence of managers at all levels of management.

For exogenous factors of the functioning of enterprises characterized by the properties of rapid changes in influence (competition, demand, prices, profitability, sales conditions), a new flexible approach to the management of sales activities is needed, providing for the priority of information tools, an in-depth study of the market based on ensuring a high level of independence, full economic responsibility of enterprises using information and communication methods.

The main condition for the functioning of agro-industrial enterprises is to make a profit. However, a number of scientists in their research note that only less than half of enterprise managers define this goal as the main one. Others mainly pointed to the need for ensuring appropriate levels of production volume, maintaining the team and an increase in wages [2, p. 136]. Based on the research data of independent experts, it has been determined that the ability to adapt to rapid changes in market conditions based on the formation of an effective management system of sales distribution channels remains an important issue today for the enterprises of the agro-industrial complex.

In the context of modern globalization and the intellectualization of the information society, the problem of increasing the competitiveness of agro-industrial enterprises through effective sales organization becomes particularly relevant, especially in terms of integration into European and world economic processes. This problem is particularly acute for the agro-industrial complex, for which Ukraine's accession to the WTO imposes a number of restrictions on its development and positioning at the foreign and domestic markets. The central element of the sales policy of enterprises is the decision to form an effective system of distribution channel management, which makes it possible to comprehensively evaluate the process of interaction between the transport network fragments and the multi-agent model of the distribution channel management system at all levels, taking into account both economic and administrative components, as well as information.

LITERATURE REVIEW

A significant number of works of foreign and domestic scientists-economists is devoted to the study of the theoretical foundations and features of improving the sales activities of agro-industrial enterprises, among which it is worth noting the scientific works of N. V. Vasyutkina [3], P. P. Gladun [4], T. G. Hryanko [5], S.B. Rozumey, M.O. Yuzvik [14], I. V. Fedosova [16], O. M. Yamkova [20]. In the studies of domestic and foreign authors, recommendations are given regarding the improvement of the level of distribution channel management of enterprises in highly competitive market conditions, methodical principles of evaluation and analysis of the development of systems of management of sales activities of enterprises are formed and substantiated.

The most significant scientific developments that highlight the problem of the distribution channel management of enterprises include the works of such domestic and foreign scientists as V. V. Aulin, A. V. Hrynkiv, A. O. Holovatyi, S. V. Lysenko, D. V. Golub, O. V. Kuzyk, A. A. Tykhyi [1], O.V. Kitura, L.N. Berkman, L.V. Dakova, S.Yu. Dakov, N.V. Blazhennyi, K.V. Polonskyi [6], E.V. Krykavskyi, O.A. Pokhilchenko, V.A. Falovich [10], R. Khraschevskii, O. Ivanets, O. Zharova [12], S.B. Rozumey, K.Yu. Semenenko, I.P. Rozputnia, M.O. Yuzvik [13-14], A. V. Shvets [17], N. P. Yurchuk [19], P. Skobelev, L. Paulo, S. Karnouskos [23].

O. Turovskyi, A. Mishchenko, V. Klobukov, O. Kitura, K. Polonskyi [6; 7; 8; 15; 22] noticed that the growing variety of types of transport networks, increasing the diversity of their constituent elements and the number of parameters that characterize the state of these elements causes an expansion of the range of approaches to the management of these networks. In their scientific works, they indicate that the principle of management of any communication network is the interaction of key control units to maintain the readiness of the communication network, the development of management processes, and their management during the tasks.

In the works of well-known scientists, the issue related to the need to properly improve the efficiency of product distribution channels in terms of the transformation of the economy had not been sufficiently considered. Therefore, the importance of developing a multi-agent model of the distribution channel management system of agro-industrial enterprises is an extremely urgent issue and needs to be resolved.

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AIMS AND OBJECTIVES

The purpose of this scientific article is to develop a multi-agent model of the distribution channel management system of agro-industrial enterprises in order to identify promising directions for the development of sales policy based on the use of information and communication methods.

METHODS

The theoretical basis of the research is the dialectical method of cognition, the conceptual provisions set forth in the works of domestic and foreign scientists on the distribution channel management of enterprises. To accomplish the assigned tasks, the following basic research methods were used: abstract-logical, abstraction, and concretization, a systematic approach, observation, and an expert evaluation method. The methodical basis of the research was general and special methods, namely: system analysis; economic and mathematical methods, tabular and graphical methods, methods of comparison and grouping, and economic and mathematical modeling in order to develop a multi-agent model of the distribution channel management system of agro-industrial enterprises.

The practical basis of the research is the development of effective management of the distribution channels of agro-industrial enterprises in terms of solving tasks of responsiveness, efficiency and reliability of informatization and communication is impossible without the development of a management information system. The Conceptual model of the MIS of DC, which has been proposed in the article, should have a number of distinctive features and capabilities and be divided into three levels: the level of organizational management, the level of operational management, and the technological level. The interaction of the MAMS and MIS occurs through controlled agents, which perform the functions of data collection and interaction with elements of the MIS, and also in the MAMS structure, there are units for data collection and interaction with each other.

RESULTS

The efficiency of the distribution channel management system of agro-industrial enterprises is characterized by a directly proportional dependence on the ability to manage it based on automated tools and means of communication. It is a well-known fact that, in the general understanding of sales management, it is an important element of the production, business, and other relations, which have the task of coordinating and harmonizing the activities of all sales channel management links. The effectiveness of management decisions in the field of sales is currently one of the most important and complex areas of management activity, which requires a deeper study through the development of a multi-agent model of the distribution channel management system of agro-industrial enterprises.

In our opinion, under the effective management of the distribution channels of agro-industrial enterprises should be understood the system of economic relations that are formed in the process of production and product sales, the organization of a rational system of product distribution, a communication system, effective personnel management, as well as planning, organization, control and analysis of an enterprise's sales activities in order to fully satisfy the needs of customers and make a profit. Sales management should be aimed at gaining and maintaining the enterprise's predominant market share and maintaining an advantage over competitors.

Therefore, the development of an effective system of the distribution channel management of agro-industrial enterprises should solve the key problems depicted in Figure 1.

Effective management of the distribution channels of agro-industrial enterprises in terms of solving tasks of responsiveness, efficiency and reliability of informatization and communication is impossible without the development of a management information system (MIS), which allows maintaining network resources at a given level, necessary to provide high-quality communication services on all distribution channels of the products.

The functioning of information management systems based on the latest technologies is impossible without upgrading the existing management system (MS) by developing network management modules that will enable the realization of all the capabilities of the MIS through distribution channels based on packet technologies. The basis of this system is the coherence and efficiency of the communication network of each channel of marketing and product sales, the management principle of which is the interaction of the key control units of the support of the communication network readiness, the development of management processes and their control during the performance of the assigned tasks in the direction of effective sales policy of agro-industrial enterprises [6, p. 11].

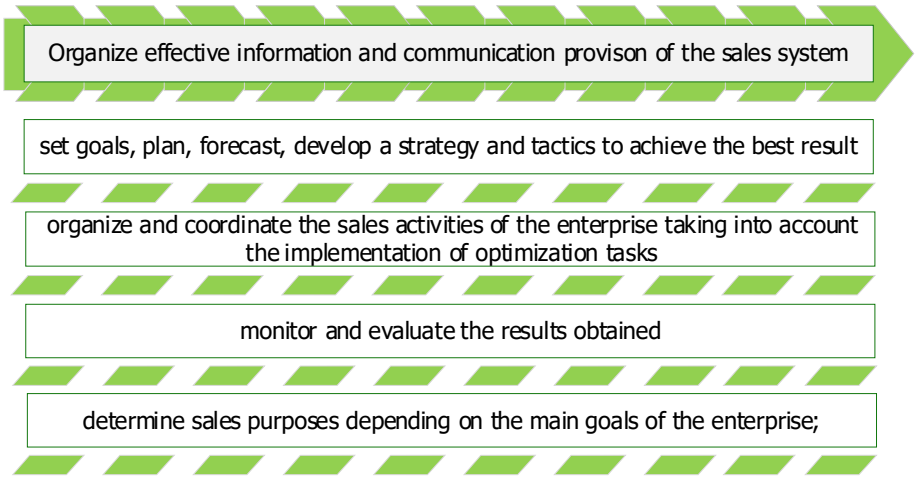

Figure 1. Key tasks of the functioning of the distribution channel management system of agro-industrial enterprises.

One of the aspects of achieving the goal of effective management of the distribution channels of enterprises is to ensure the use of all functions of communication networks in solving the assigned tasks, the main of which are: the collection, processing, and analysis of network state data; preparation and decision-making to eliminate failures and malfunctions; development of documents; bringing tasks to performers; organization and maintenance of interaction of subsystems; organization of management in the performance of tasks; control of subsystems [8, p. 37].

The main indicator of the quality of the functioning of the MIS by distribution channels is the efficiency of making managerial decisions regarding the state of the communication network in terms of high dynamics of changes in the states of the transport communication network. Among many different factors that can affect the indicated efficiency, we can single out a number of factors related to the need to form a set of decisions to change the configurations of individual communication routes depending on the state of individual nodes, if the optimal option is agreed with the decision maker, which, in fact, is a rather complex organizational process associated with the possibility of using elements of artificial intelligence [11, p. 92].

At present, in the development of new principles and methods of managing complex processes (such as sales management), multi-agent technologies - technologies for the development and application of multi-agent systems - complex systems that function with the help of several intelligent agents, the process of self-organization of which is reduced to coherence, orderliness, the interaction of agents among themselves, have found wide use. The application of this approach will enable, in addition to solving the important task of choosing the optimal control option for changing the configuration of data transmission routes, a preliminary assessment of the duration of the management cycle generated by the system, as well as through the use of a hierarchical approach to building an MIS by distribution channels using multi-agent technologies at the organizational and economic and technological levels of management [13]. It is the application of multi-agent technologies in the development of the MIS of distribution channels of enterprises that will significantly increase the efficiency of its functioning, and improve the efficiency of decision-making regarding the management of product sales channels in terms of rapid dynamics of changes in the state of individual network elements of the system.

At the same time, the stage of creating the MIS of distribution channels of agro-industrial enterprises based on a multi-agent management system (MAMS) is preceded by the stage of developing a structural diagram of the indicated MAMS. The growing variety of communication network types, the increase in the heterogeneity of its constituent elements and the number of parameters characterizing the state of these elements require an expansion of the range of approaches to managing distribution channels. One of the approaches to enhance the efficiency of the MIS is to improve and increase the efficiency of the functioning of subsystems in order to increase the level of the MIS responsiveness to changes in the state of network elements. One of the ways to increase the specified efficiency is to create an MIS based on multi-agent technologies. Solving this task at the first stage involves the development of the structure of a multi-agent system of the distribution channel management of agro-industrial enterprises.

The proposed conceptual model of the MIS of DC should have a number of distinctive features and capabilities. Namely such as [15, 16, 22]:

- the availability of information links between the components of the MIS;

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- the possibility of defining management goals;
- the presence of the MAMS, which enables, in the presence of a configuration control unit, to form a set of decisions for changes in the configuration of individual routes, fragments and the entire MIS, and the selection of the most optimal ones is agreed with the manager, who makes the optimal decision regarding the selection of a route;
- the possibility of choosing an acceptable process of control and management of the state of the elements of the control object;
- a preliminary assessment of the duration of the management cycle, which is formed by the MAMS and agreed with the decision maker;
- distribution of MAMS on different levels of MIS building allows to control and manage the state of individual elements at different levels.

In order to ensure high efficiency of functioning and ensure high quality of performance of tasks, the MIS of DC will be divided into three levels [4, 15, 19].

1. The level of organizational management - the development of organizational decisions on the long-term functioning of the MIS. At this level, there is a need to have a database and the necessary information about the state of the MIS of DC at any given time.
2. The level of operational management - providing a set of management mechanisms and ready-made management decisions that are combined into an action plan for the reconfiguration of the transport network. To do this, at the specified level, it is necessary to have [6, 16, 27]:
    - subsystem of control, administration and management;
    - subsystem of formation of connected routes;
    - subsystem of determination of control mechanisms as part of the overall management process;
    - subsystem of formation of transport network reconfiguration.
3. Technological level - ensuring the collection of operational characteristics of the MIS and their processing; automatic management of the state of technical means of the transport network; the choice of the management process, which is determined by the management mechanism defined at the highest level. To perform the above tasks at the technological level of management, it is necessary to have a subsystem of information collection, a subsystem of control and management of the state of the elements of the MIS of DC of agro-industrial enterprises. Schematically defined levels of MAMS and their interrelation are presented in Figure 2.

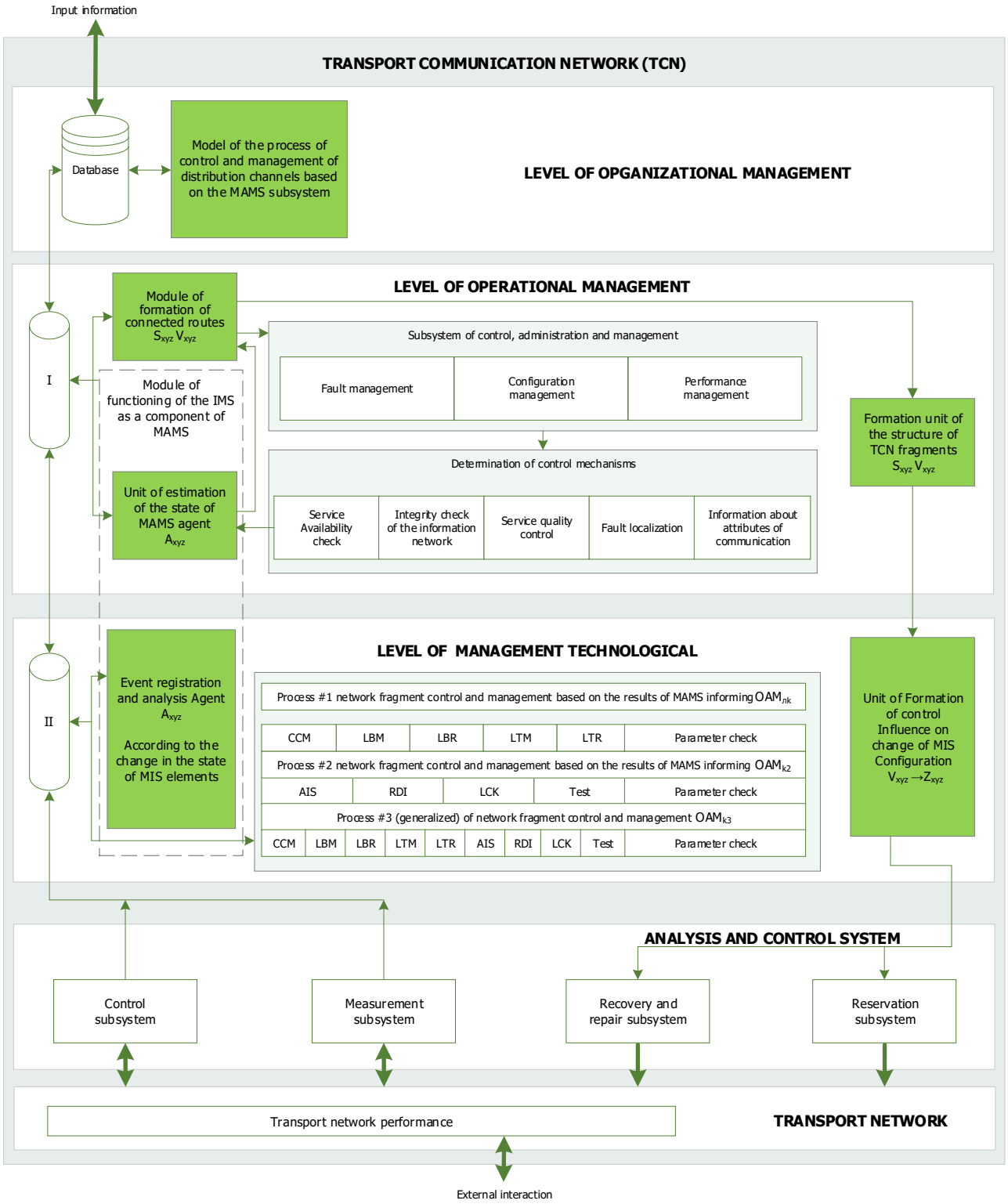

Figure 2. Conceptual model of MIS of distribution channels of agro-industrial enterprises. *(Source: developed by the author based on sources [4; 6; 15; 22])*

In accordance with the structure of the promising multi-agent distribution channel management system shown in Figure 3, the interaction of the MAMS and MIS occurs through controlled agents. These agents perform the functions of data collection and interaction with elements of the MIS (A_REG), and also in the MAMS structure, there are units for data collection and interaction with each other (A_(STATE) and A_STR). These data are subsequently used to form a fragment of the transport network structure when calculating the objective function (OF) of the multi-agent community [15, 20, 21].

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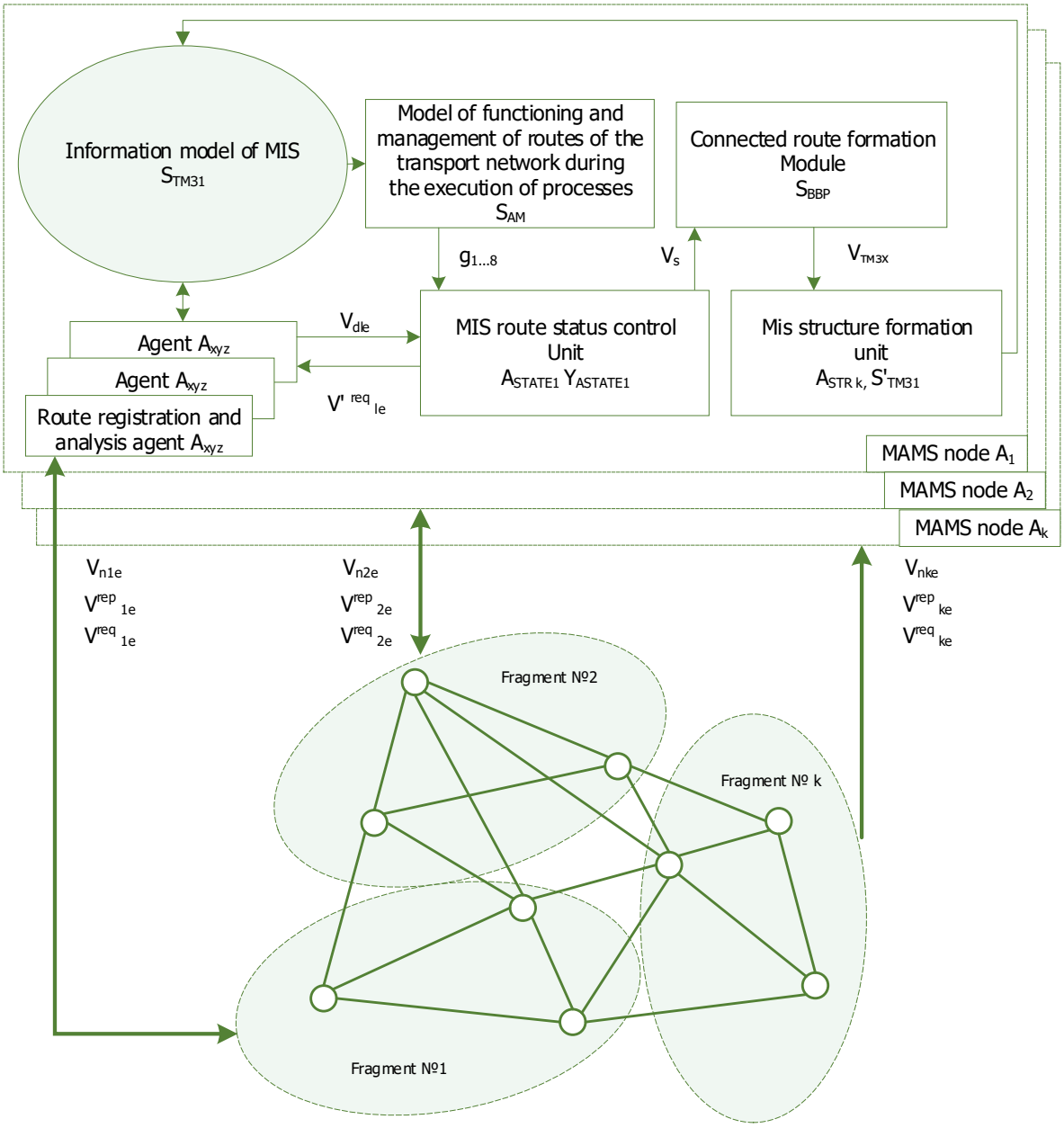

Figure 3. The structure of the multi-agent model of the information system of distribution channel management of enterprises. *(Source: developed by the author based on sources [15])*

In this aspect, the assessment of the duration of the state control cycle of the MIS elements is relevant. For this, it is convenient to use sequential evaluation algorithms. The most suitable of these types of algorithms in terms of computational complexity, accuracy and speed of the results obtained is the Robinson-Monroe algorithm [14, 15].

Let us consider the process of interaction between the MAMS agent and the MIS element in the management process. The scheme of such interaction is shown in Figure 4. In the MIS, we will allocate a resource for the transfer of control and management information between interconnected elements and the relevant agents of the MAMS. In this case, the agent is an information display of the MIS element in the MAMS.

In the process of management, the following types of input information control can be distinguished in the case of external interaction of the MAMS agents with the interconnected elements of the ICS of distribution channels [17, 22]:

- survey by the information registration and analysis agent (AREGi) of the values of the element parameters and subsequently responses of the element. This amount of data will be denoted by V_p. And the frequency with which this operation is performed is v_p. According to the interaction scheme (see Figure 2.1), the amount of data in a survey of a parameter consists of a request and a response. And this means that:

$$V_p = V_p^{req} + V_p^{rep} \quad (1)$$

- requests for the execution of agent control commands A_{REGi} – LBM i LTM, as well as the further transmission of data on the application of these MIS commands. The volumes of these requests and the frequency of data transmission are presented in Table 1, and the entire amount of transmitted data when executing control commands will be determined by the expression:

$$V_{OAM} = V_{OAM}^{req} + V_{OAM}^{rep} \quad (2)$$

- notification (without a preliminary survey) by an element of the MIS of distribution channels. This amount of data will be denoted by V_n . And the frequency with which this operation is performed is v_n.

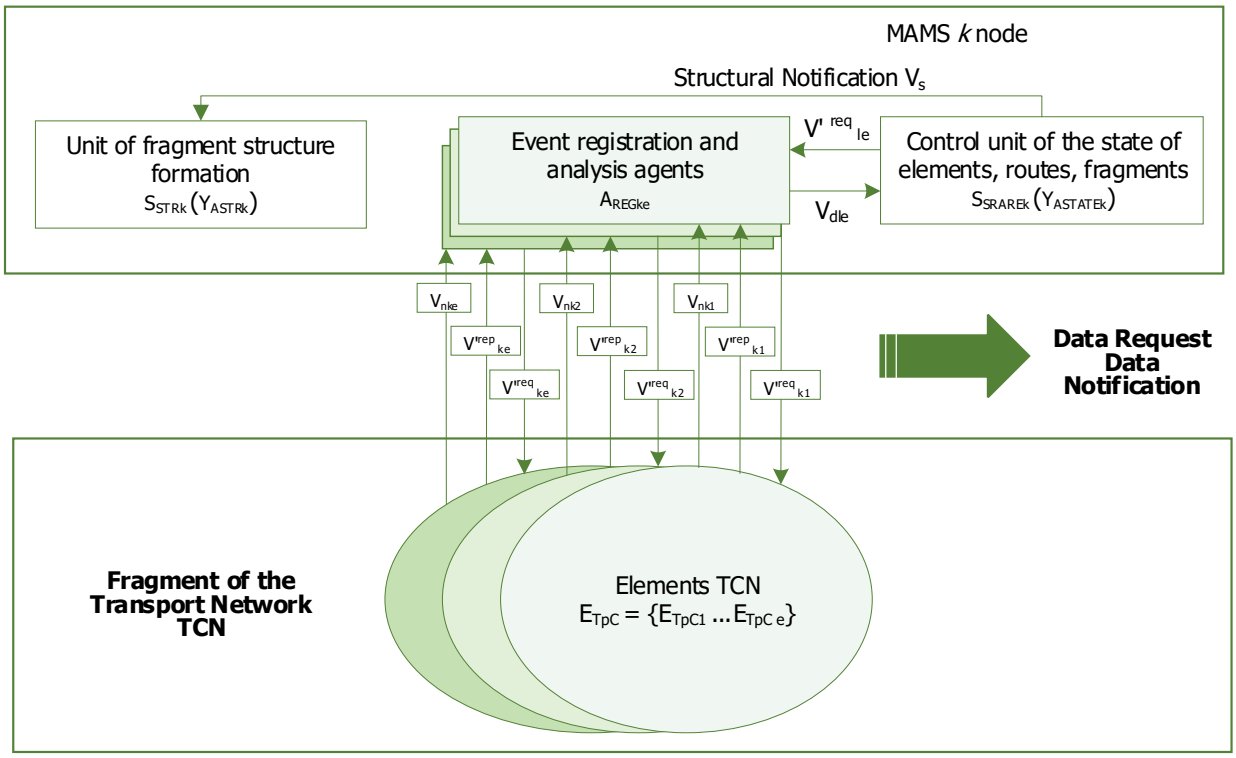

Figure 4. Model of interaction between the MAMS agent and the MIS element in the distribution channel management process. *(Source: developed by the author based on sources [15-17])*

It should also be noted that control agents interact with other MAMS control elements, thereby organizing internal interaction. Let us assume and limit ourselves to the fact that the only possible type of interaction between control units and agents is the message types "request", "data" and "message". Then we can distinguish the types of messages transmitted between control agents:

- state evaluation survey (A_{STATE}) of the registration and analysis agent (A_{REG}) about the state of an element, which is subordinate to this fragment of the system. In this case, the volume and frequency of the transmitted message will be denoted by V_p' and v_p', respectively. According to the interaction scheme, the amount of data consists of a request and a response (see Table 2). And this means that:

$$V_p' = V_p'^{req} = V_p'^{rep} \quad (3)$$

- data received by the unit A_{STATE} about the messages of the element of the MIS of distribution channels, in particular, information about checking the connectivity of routes.

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Table 1. Parameters of external messages of the MAMS agent. *(Source: developed by the author based on sources [20-22])*

Message type	Transmitted control data	Amount of data in the survey	Request frequency (v) or data transmission time (T)
Request	Control command OAM (Operation, Administration, Maintenance)	V_{OAM}^{req}	v^{OAM}
	Element parameters	V_p^{req}	v^p
Data	Control command OAM (Operation, Administration, Maintenance)	V_{OAM}^{rep}	T^{OAM}
	Element parameters	V_p^{rep}	T^p
Element notification	Failure indication OAM (Operation, Administration, Maintenance)	V_n	v^n

Table 2. Parameters of internal messages of the MAMS agent. *(Source: developed by the author based on sources [20-22])*

Message type	Transmitted control data	Amount of data in the survey	Request frequency (v) or data transmission time (T)
Data	Element parameters	V_p^{rrep}	T^{rp}
	Failure indication OAM (Operation, Administration, Maintenance) Control command OAM (Operation, Administration, Maintenance)	V_d	v^d
Notification about structural changes	Evaluation of transport routes	V_s	v^s

Considering the fact that the process of generating decision options is launched inside the unit ASTR, then the key for the resulting decision-making time will be the time of collecting information about the state of the MIS elements by agents AREG, a survey by the unit ASTATE and messages of the unit ASTR.

Thus, the set of messages of the MAMS elements can be divided into the set of external messages that are received by the agents A_{REG} of the MIS element and internal messages that are exchanged by the control units of the current node of the MAMS. The total decision-making time of the unit A_{STRi} will consist of the time spent by the node's agents on receiving and transmitting internal and external messages.

Thus, the messages arising from the interaction of the MIS elements with the MAMS elements can be classified as:

- direct requests for the parameters of MIS elements. In this case, the receiver (MIS element) sends a response message with data parameters via the feedback channel;
- notifications to the element about the emergency state are included in the loop of control and management of malfunctions of interconnected elements of the MIS;
- indirect requests for optimization of MIS parameters;
- requests for the execution of commands included both in the external control loop and partially in the internal control loop of the MAMS elements. Such requests also require an appropriate notification from the recipient;
- notifications about structural changes are included in the internal control loop of the MAMS elements.

DISCUSSION

One of the achieving aspects of scientific research in the direction of effective management of agro-industrial enterprises' distribution channels was to ensure the use of all transport communication functions in the process of solving the setting tasks set in the research. Achieving this goal involved solving a number of tasks, the main of which are: collection, processing and analysis of data of the transport network state; preparation and decision-making to eliminate failures and malfunctions; documents development of; delivery of tasks to executors; organization and maintenance of interaction of subsystems; organization of management during the execution of tasks; reservation and control of subsystems operation. The basis of this system is the coherence and efficiency of the communication network of each channel of marketing and product sales, the management principle of which is the interaction of the key control units of the support of the communication network readiness, the development of management processes and their control during the performance of the assigned tasks in the direction of effective sales policy of agro-industrial enterprises.

Currently, in the scientific works of well-known scientists in the direction of the development of new principles and methods of managing complex processes have found widespread use of multi-agent technologies - technology development and application of multi-agent systems - complex systems operating with multiple intelligent agents. The papers solve the scientific problem of developing a promising structure of a multi-agent system for managing a transport communication network based on carrier ethernet technology.

In contradistinction to previously developed and implemented distribution channel management systems of agro-industrial enterprises, a multi-agent model of the distribution channel management system which is developed in the article, makes it possible to comprehensively evaluate the process of interaction between the transport network fragments and the multi-agent model of the distribution channel management system at all levels, taking into account both economic and administrative components, as well as information.

CONCLUSIONS

Thus, the results of the research on the development of the multi-agent model of the distribution channel management system of agro-industrial enterprises made it possible to draw certain conclusions regarding further simulation of the processes of distribution channel management of enterprises in order to assess the duration of the entire management cycle and the compliance of these indicators with the necessary specified parameters. In this regard, we have highlighted the key results of the research, namely:

- the interdependent processes of the interaction between MIS elements and the multi-agent model of the distribution channel management system of agro-industrial enterprises are modeled;
- the peculiarities of the functioning of the MIS and the potential opportunities for functioning as intended are determined.

The three-level conceptual model of the MIS of distribution channels of agro-industrial enterprises is presented, indicating the role and place of the MIS. This model defines:

- the level of organizational management;
- the level of operational management;
- the level of technological management.

The model of interaction between the MAMS agent and the MIS element in the process of managing distribution channels has been developed. The specified model enables the simulation of the management processes of the MAMS agents and the elements of the MIS of distribution channels.

Therefore, the result obtained during the simulation of the interaction between the MAMS and the MIS of distribution channels is the starting point for further simulation modeling of the management processes of distribution channels of agro-industrial enterprises in order to assess the duration of the entire management cycle and the compliance of these indicators with the necessary specified parameters. The obtained result makes it possible to develop a number of requirements for the prospects of improvement of the MIS of distribution channels for a reasonable choice of the processing time of input and output information within the framework of control and management processes of the state of the system elements.

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МУЛЬТИАГЕНТНА МОДЕЛЬ СИСТЕМИ УПРАВЛІННЯ КАНАЛАМИ РОЗПОДІЛУ АГРОПРОМИСЛОВИХ ПІДПРИЄМСТВ

Метою даної наукової статті є розробка мультиагентної моделі системи управління каналами збуту агропромислових підприємств із метою визначення перспективних напрямів розвитку збутової політики на основі використання інформаційно-комунікаційних методів.

Для досягнення поставленої мети було проведене дослідження діалектичного методу пізнання, концептуальних положень, викладених у працях вітчизняних та зарубіжних учених із розподілу каналів управління підприємствами. Для виконання поставлених завдань були використані такі основні методи дослідження: абстрактно-логічний, абстрагування та конкретизації, системний підхід, спостереження, метод експертної оцінки. Методичну основу дослідження склали загальні та спеціальні методи, а саме: системний аналіз; економіко-математичні методи, табличо-графічні методи, методи порівняння та групування, економіко-математичне моделювання з метою розробки мультиагентної моделі системи управління каналом збуту агропромислових підприємств.

Установлено, що зростання потреби в розробці ефективної інформаційної системи управління каналами збуту агропромислових підприємств, збільшення неоднорідності складових елементів і кількості параметрів системи збуту вимагає розширення діапазону методичних підходів до управління каналами збуту в напрямі моделювання системи управління каналами збуту підприємств. Зокрема, це є принциповим при вирішенні проблем організації та оперативно-технічного управління транспортною розподільчою мережею.

Водночас визначити перспективні напрями розвитку збутової політики з використанням інформаційно-комунікаційних методів на основі нових технологій неможливо без модернізації існуючої системи управління шляхом розробки інформаційної системи управління, яка в перспективі дозволить реалізувати всі потенційні можливості для ефективної та оперативної транспортної мережі на основі пакетних технологій.

Таким чином, у зв’язку із суттєвим розвитком сучасних інформаційно-комунікаційних технологій, зміною процесів функціонування елементів системи управління каналами збуту агропромислових підприємств та їх взаємодії, зміною механізмів моніторингу функціонування елементів системи виникає необхідність розробки нової архітектури інформаційної системи управління каналами збуту з метою підвищення рівня конкурентних переваг підприємства в довгостроковій перспективі.

Ключові слова: агропромислове підприємство, система управління каналами збуту, інформаційна система управління, мультиагентна система управління, управління збутом, мультиагентні технології

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