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Digitalizing an integrated logistics flows of a focus enterprise

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Abstract

The purpose of the study is to clarify and supplement the theory and methodology of design, formation, and optimization of management of integrated, homogeneous, and heterogeneous flows of material, information, financial, and human resources in channels, chains, fronts, echelons, and networks of various types. The descriptor and facet classification methods and methods of analysis and synthesis, induction and deduction have been chosen as research methods, and binary matrices formed on the basis of qualitative attributes and dichotomies of objects and components of integrated logistics flows management were used as tools. The variants of business system management subjects and objects integration have been substantiated. An end-to-end classification of enterprises and relations among them, processes, and logistics operations has been developed for the purpose of digitalization of integrated logistics flows and business systems of various types. The variants of these flows have been defined and digitized, and theoretical and methodological prerequisites for modeling these flows have been created. The value of the study lies in theoretical and methodological prerequisites creation for digitalization of non-physical subjects and objects of integrated logistics flows management, as well as their integration with other physical subjects and objects in order to develop rational management decisions both at the level of links and at the level of the business system.

Keywords

Integration, logistics, flow, digitalization, business system, model, digital twin prototype, management

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Цифровизация интегрированных логистических потоков фокусного предприятия

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Аннотация

Целью настоящего исследования является уточнение и дополнение теории и методологии проектирования, формирования и оптимизации управления интегрированными, гомогенными и гетерогенными потоками материальных, информационных, финансовых и человеческих ресурсов в каналах, цепях, фронтах, эшелонах и сетях различного типа. В качестве методов исследования выбраны дескрипторный и фасетный методы классификации, методы анализа и синтеза, индукции и дедукции, а в качестве инструментов использованы бинарные матрицы, сформированные на основе качественных признаков и дихотомий объектов и компонентов управления интегрированными логистическими потоками. Обоснованы варианты интеграции субъектов и объектов управления бизнес-системой. Разработана сквозная классификация предприятий и отношений между ними, процессов и логистических операций с целью цифровизации интегрированных логистических потоков и бизнес-систем различного типа. Определены и оцифрованы варианты данных потоков, а также созданы теоретические и методические предпосылки для моделирования данных потоков. Ценность исследования заключается в создании теоретических и методических предпосылок для цифровизации нефизических субъектов и объектов управления интегрированными логистическими потоками, а также их интеграции с прочими физическими субъектами и объектами с целью выработки рациональных управленческих решений как на уровне звеньев, так и на уровне бизнес-системы.

Ключевые слова

Интеграция, логистика, поток, цифровизация, бизнес-система, модель, прототип цифрового двойника, управление

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INTRODUCTION

The use of computer technology in making management decisions improves their quality and contributes to the competitiveness of supply chains by reducing lost profits and the loyalty of end users of products and services. However, the solution to this problem is accompanied by a number of negative factors such as:

– complexity of the study of diverse business systems such as channels, chains, fronts, echelons, and networks, the theory and methodology of design, formation and optimization of which require improvement;

– presence of several objects of business systems management, which include enterprises, relations, processes and flows that have a complex structure [1];

– need to consider the specifics and behavioral options of a significant number of persons making management decisions (management subjects), due to which each link of the business system can achieve its own goals to the detriment of its purpose;

– limited possibilities of measurement, identification and digitalization of non-physical subjects and objects of business system management, namely values and behavior of end users of products and services, relations in the system, managerial decisions of its links, goals, objectives and management principles, environmental factors, etc. The creation and implementation of a business system is particularly difficult.

The issues of structuring, digitalization and modeling of integrated flows of material, informational, financial and human resources, which are the objects of logistics research, represent a special difficulty in the creation and implementation of information technologies, in particular, digital twins of business systems management. These issues are still unsolved due to the unreasonable inclusion of the management object "flow" in the competence of supply chain management, as a result of which the attention of specialists has shifted to the management object "chain", the essence and content of which cannot be specified without specifying the essence and content of the first object [2]. Orientation to the management of not one, but several resource flows simultaneously or integrated, including heterogeneous, or logistic, flow creates a number of competitive advantages to create a value stream of end users of products and services, eliminate inter-organizational and inter-functional barriers in business systems and improve the quality of products and services.

This study is the first to propose an end-to-end classification of business systems management objects: enterprises, relations and processes, on the basis of which the basic variants of integrated logistics flows are defined and theoretical and methodological prerequisites for their digitalization, structuring, standardization, modeling and subsequent design of a prototype of a digital twin of business systems management including physical and non-physical subjects and management objects with further creation of their instances and aggregates are created

Within the framework of the research the following tasks are supposed to be solved:

– substantiation of variants of integration of subjects and objects of business system management;

– development of end-to-end classification of enterprises and relations between them, management objects, processes and logistics operations for the purpose of digitalization of business systems of different types;

– determination of variants of integrated logistic resource flows, as well as their ciphers and codes;

– creation of theoretical and methodological prerequisites for modeling these flows in various management situations.

LITERATURE REVIEW

The terms "integration" and "integrated" are widely and unevenly spread in the theory and methodology of business systems management and logistics management. The study of the literature on this aspect has revealed several variants of their use.

1. Option of clarifying the essence and content of these terms in general and on the main objects of business system management in particular, because "this word has many meanings that are misunderstood" [4]. Applied to management, the definition of the term "integration" can be as follows – "the quality of interaction that exists between units, necessary to achieve unity of effort in accordance with the requirements of the environment" [5].

It follows that integration is internal to the management object "enterprise". In addition, the terms "integration of relations" and "integration of processes" are objects of research [6; 7]. Combinations of the words "flow" and "integration", as well as "movement" and "integration", are also found in the literature, but in the first case they characterize the sphere of information flow management, and in the second case – "continuous collection and movement of any corporate data in real time" [8; 9]. This means that the task of creating the theory and methodology of integrated, primarily material, flows management is not considered relevant at the moment.

2. Variant of the relationship between the terms "integration" and "logistics", since "logistics integration refers to the operational activities that coordinate the flow of materials from suppliers to customers", and these activities refer to the competencies of logistics management, integrated logistics management, and, finally, "integrated logistics" [10–14]. This aspect of the study once again confirms the complexity of digitalization of business system management objects without finalizing the content of terminological dictionaries.

3. Option of creating logistics business systems, such as "integrated logistics management system", "integrated distribution system", designed to influence logistics resource flows in accordance with the "integrated physical distribution management concept", as it is designed to provide effective service to end users of products and services [15–17].

4. Option of developing and using hierarchically interrelated "integrated logistics strategies" and "integrated supply chain strategies", which can be used by a set of links of the business system or at the level of functional areas of business system management, including logistics management [18; 19].

5. Option to consider the structure of the "integrated supply chain" formed with the help of "supply chain integration" [20; 21]. The last integration option is designed to "provide efficient flows of products, services, information, money and solutions to maximize value for its customers" [22].

6. Deficit of terms close in content to the term "integrated resource flow", which is further planned to be structured, digitized and modeled. At the moment, specialists have proposed the terms "integration of flows in the supply chain", "integration of logistics resources" and "integration of information flows" [23–25]. The authors of this study failed to find information on the integration of material, financial and human flows on both homogeneous and heterogeneous features, although it is this feature that gives the necessary specificity to the study.

Thus, the study of the literature allowed us to come to the following conclusions:

– despite the importance of integrated logistics flow management, specialists do not use the term reflecting its essence and content, or it is not known to them;

– the theory and methodology of this type of flow management is not well developed, although for end users of products and services their flows or value flows are more important than the business systems that produce and move them;

– one of the main reasons for this problem is the premature refusal of specialists to study the term "flow" and logically unjustified transition to the study of the term "supply chain" – since supply is a process, the main object of integration has become not flows, but processes, as exemplified, in particular, by such information products as SCOR and DCOR models;

– the terms of logistics and business chain management, which include the words "integration" and "integrated", do not represent a coherent system of elements, which makes qualitative digitalization of these terms problematic;

– the vast majority of the above terms are non-physical management objects that are difficult to measure, therefore the theory and methodology of creating digital twins of physical supply chain objects cannot be the basis for creating digital twins of business chain management and integrated logistics flows.

In this study, the integrated logistics flow will be understood as a set of homogeneous and heterogeneous objects and components moving in space and time and adapted to quantitative and qualitative changes in accordance with the impact on them of the management subject.

RESEARCH METHODOLOGY

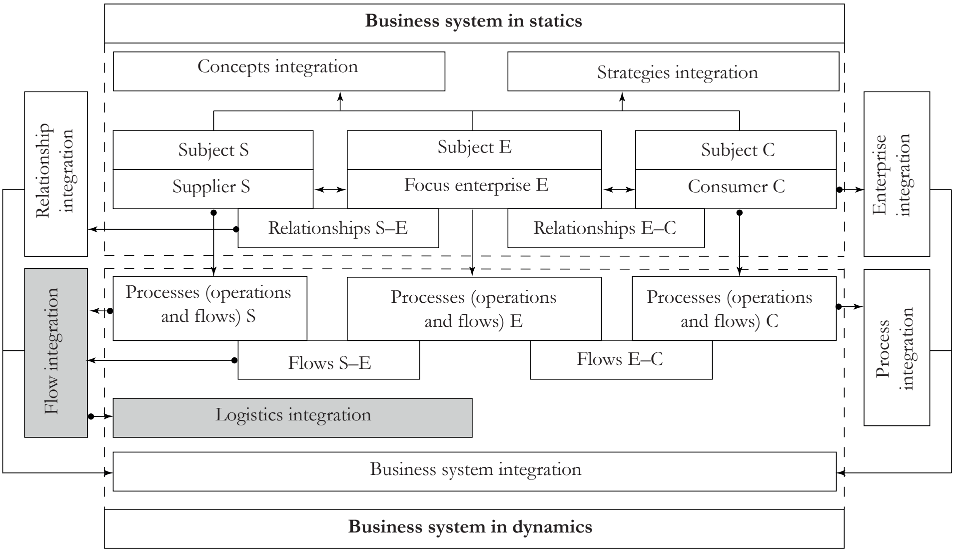
Since business system and business system management are complex both in terms of structure and use cases, their digital twins consist of a set of digital twins of not only physical (transportation, warehouses, stocks, containers, machines, equipment, etc.) but also non-physical objects. The greatest difficulty in creating digital doubles of this type is the issue of substantiation of scales and measurement tools for non-physical objects. In this regard, qualitative methods have been chosen as the main research methods, which include:

– descriptor method, based on determining a set of actual qualitative attributes of subjects and objects of management and their dichotomies or bifurcations, providing for a consistent division of subjects and objects into two parts, more connected within than between themselves – these attributes and dichotomies are determined by analyzing literary sources and sociological surveys;

– facet method, which allows to determine rational combinations of actual qualitative attributes two, three or more at a time and identify different variants of subjects and objects of business system management, located in the cells of binary matrices (for example, the joint use of two qualitative attributes and their dichotomies allows to obtain four variants of a subject or object of management, three attributes used simultaneously contribute to the justification of 8 of their variants, etc.).

RESEARCH RESULTS

Achievement of the research objective should be systemic in nature. In other words, it is necessary to show the place of the research object "integrated logistics flow" in the management of business systems. One of the solutions to this problem is presented in Fig. 1.



Compiled by the authors on the materials of the study

Fig. 1. Business system structure and variants for management subjects and objects integration

The content of the figure allows us to draw the following conclusions:

– it is reasonable to distinguish between business chains in static (enterprises and relations between them) and business chains in dynamic (processes and resource flows connecting them), while at the enterprise level it is necessary to distinguish management subjects or persons making management decisions and executors related to the fulfillment of consumers' orders;

– a typical business chain includes three management objects: supplier "S", focus enterprise "E" and consumer "C", connected by relations "S–E" and "E–C" and performing processes consisting of operations and internal flows for enterprises, as well as processing incoming and outgoing resource flows "S–E" and "E–C";

– each management object develops and implements a management concept and strategy, which implies the harmonization of their content and the formation of an integrated concept and strategy;

– it is expedient to solve the problem of integration of the main objects of business chain management: enterprises, relations, processes, and flows (the last variant of integration can be called logistic integration).

The research methodology allows not only to obtain new variants of known solutions, but also to confirm the correctness of these solutions, thus creating theoretical prerequisites for digitalization of the subjects and objects under study. Since the management of integrated logistics flows implies the selection of specific management objects related to it in terms of quantity and quality in one or another of their combinations, it is advisable to develop an end-to-end classification of these objects, which contributes to the formation of a logically sound system of ciphers and codes used in their digitalization.

In order to define the role of an enterprise managing integrated logistics flows, it is advisable to use the following attributes and dichotomies:

– "type of values created by the enterprise": intangible (symbol "0") and tangible (symbol "1");

– "type of function of the management subject": supply of resources (symbol "0") and processing of resources (symbol "1").

The combined use of these attributes and dichotomies allows us to determine that the primary role of this enterprise is the role of "logistician" (code "10") along with such roles as "partner" (code "00"), "owner" (code "01") and "technologist" (code "11"). Thus, the initial code for digitalization of the integrated logistics flow is code "10".

The enterprise as a management object has the minimum necessary property to ensure effective management not only of integrated logistics flows, but also of its components (hereinafter referred to as jets), with each type of property creating prerequisites for the allocation of a local jet of this flow. To substantiate these components, it is recommended to use the following qualitative attributes and dichotomies:

– "autonomy of the objects of the integrated logistics flow": autonomous (symbol "0") and non-autonomous (symbol "1");

– "purpose of the objects of the integrated logistic flow": contributing to the solution of the problem (symbol "0") and solving this problem (symbol "1").

On the basis of these attributes and dichotomies, a binary matrix can be created, in the cells of which the following management components are located: lifting and transport vehicle (code "00"), packaging (code "01"), vehicle (code "10") and material resource (code "11") in a certain quantity and quality, considered either as a "product" or as a "batch". An enterprise acting as a logistician (code "10"), acting, for example, on a vehicle (code "10"), forms a more complex business system control object, which is coded "10.10".

The management object "relationships" is also characterized by diversity, which can be ordered by qualitative attributes and dichotomies such as:

– "duration of the relationship": short (symbol "0") and long (symbol "1");

– "presence of a common goal with the counterparty (supplier S or consumer C)": no (symbol "0") and yes (symbol "1");

– "priority of the counterparty in decision-making": no (symbol "0") and yes (symbol "1").

The joint use of these attributes and dichotomies allows to justify 8 variants of relations of the investigated enterprise with the counterparty (Table 1).

If the entity is in a long-term relationship, has a common purpose and considers the priority of the counterparty, the code "111" should be added to the previously obtained code "10.10", and the result is that the researcher can use the 7-digit code "10.10.111", indicating the trust relationship of the entity affecting the vehicle used for the benefit of the counterparty or for its own purposes.

If we set the task of classifying the object "process", the operations performed by the components of management may coincide and at the same time differ. Taking this aspect into account, it is reasonable to justify a two-level classification of processes performed with control components, which can be represented in motion, i.e. as jets and as an integrated logistic flow. The first level of classification is aimed at the allocation of basic, or unified, processes. To solve this problem, it is advisable to use the following qualitative attributes and dichotomies:

– "purpose of impact on management components": creation of value (symbol "0") and preservation of consumer properties (symbol "1");

– "life cycle stages of management components": creation and decline (symbol "0"), development and maturity (symbol "1").

The combined use of these attributes and dichotomies allows us to justify the four basic processes performed by the enterprise in the role of the logistician:

– acquisition (manufacturing), code "00";
– storage (processing/disposal), code "01";
– use (operation), code "10";
– preparation (maintenance and repair), code "11".

Table 1

Classification of types of relationships among integrated logistics flow management subjects (counterparties)

Classification attributes			Relationships types
Duration of the relationships: short (0); long (1)	**Having a common goal: no (0); yes (1)**	**Priority of the counterparty: no (0); yes (1)**	
0	0	0	Uncertainty
0	0	1	Dictate
0	1	0	Interaction
0	1	1	Subordination
1	0	0	Cooperation
1	0	1	Force
1	1	0	Partnership
1	1	1	Trustworthiness

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To justify each of them, it is necessary to use relevant qualitative attributes and their dichotomies, which is the task of future research. For further classification of the management object "process", let us take as a basis such its type as "use (operation)", code "10".

Considering that some control components are autonomous (lifting and transportation and transportation means, symbol "1") and others are non-autonomous (packaging and resource, symbol "0"), the logistic operations performed by them are different. For example, to justify the quantity and quality of operations performed by autonomous management components, it is reasonable to use the following qualitative attributes and dichotomies:

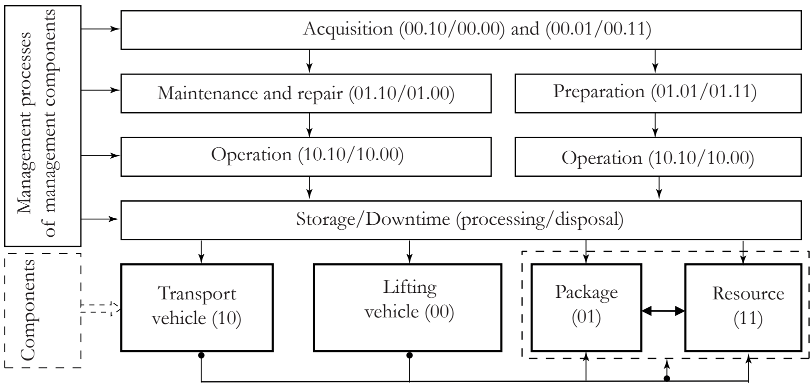
– "component 'place' of the marketing complex": place of acceptance (symbol "0") and place of transfer (symbol "1");

– "type of logistic operation": initial-final (symbol "0") and main (symbol "1").

These attributes and dichotomies allow to justify four logistic operations performed by autonomous control components: connection (code "s", code "1.00"), disconnection (code "r", code "1.01"), maneuvering (code "m", code "1.10"), and transportation (code "t", code "1.11").

Similarly, when the same qualitative attributes and dichotomies are used together, logistics operations performed by non-autonomous control components, such as storage (code "h", code "0.00"), warehousing (code "w", code "0.01"), manipulation (code "n", code "0.10") and movement (code "p", code "0.11"), can be defined. The division of logistics operations on the basis of the autonomy of the control component is relevant from the point of view of defining and assigning the owner of the logistics operation or the owner of this component, interested in its maximum efficiency. In this case, the logistics operations "storage" or "downtime" also apply to autonomous control components.

The information outlined above allows us to establish interrelationships and digitize the management components of the integrated logistics flow, as well as the processes performed by them (Fig. 2).



Compiled by the authors based on the research materials

Fig. 2. Relations and codes of integrated logistics flow management components, as well as logistics processes and operations

The upper part of the figure shows the processes performed by the vehicle (code "10") and the material handling vehicle (code "00"), and the processes related to the impact on the package (code "01") and the resource (code "11"). Each process is labeled with a four-digit binary code, the first part of which contains the process code and the second part contains the control component code. The lower part of the figure reflects the possibilities of transportation by transportation and lifting means of the package and the resource individually and the resource in the package.

Each of the control components can move (be transported or moved) and in this regard be considered as a stream or part of an integrated logistics flow. The joint movement of two or more jets creates prerequisites for the study of integrated logistic flows, which can be elementary in the case of joint movement of control components (a sea vessel with material resources) or complex in the case of parallel movement of several autonomous control components (types of urban passenger transport). Let us consider the simplest case of formation of elementary integrated flows of control components.

Since these flows are based on four control components, 16 variants of integrated flows can be identified on their basis, with one of them with the code "0000" representing a stock, four variants can be considered as jets, 6 – as two-component integrated flows, three - as three-component integrated flows, one – as a four-component integrated flow (Table 2).

Table 2

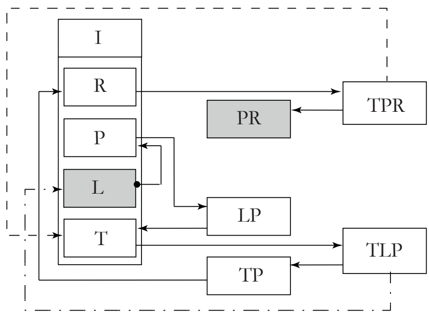
Options for integrated logistics flows (operation/use process)

Transport vehicle (T)	Lifting vehicle (L)	Package (P)	Resource (R)	Variant ciphers
Flow objects code				
1000	1001	1010	1011	
0	0	0	0	Inventory (I)
0	0	0	1	R
0	0	1	0	P
0	0	1	1	P1R2
0	1	0	0	L
0	1	0	1	L1R2
0	1	1	0	L1P2
0	1	1	1	(LP)1R2; (LR)1P2; (RP)1L2; LPR
1	0	0	0	T
1	0	0	1	T1R2
1	0	1	0	T1P2
1	0	1	1	(TP)1R2; (TR)1P2; (RP)1T2; TPR
1	1	0	0	T1L2
1	1	0	1	(TL)1R2; (TR)1L2; (LR)1T2; TLR
1	1	1	0	(TL)1P2; (TP)1L2; (LP)1T2; TLP
1	1	1	1	(TL)1(PR)2; (TP)1(LR)2; (TR)1(LP)2; (TLP)1(R)2; (TPR)1(L)2; (LPR)1(T)2; (TLR)1(P)2; TLPR

Compiled by the authors on the materials of the study

The information presented in the table allows us to draw the following conclusions.

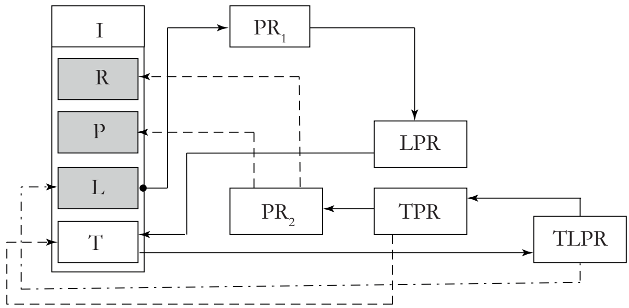
1. Integrated logistics flows can be created according to the principle "from simple to complex", and vice versa.
2. The content of the table can be specified or adapted to certain management tasks, for example, "packing of the resource" and "separation of the packaging from the resource" using transport and lifting vehicles (Fig. 3, Fig. 4).



Note: I – Inventory, L – Lifting vehicle, T – Transport vehicle, R – Resource, P – Packaging

Compiled by the authors based on the research materials

Fig. 3. Management model of integrated flows focused on resource packaging (PR)



Note: I – Inventory, L – Lifting vehicle, T – Transport vehicle, R – Resource, P – Packaging

Compiled by the authors based on the research materials

Fig. 4. Integrated flow management model focused on separating the package (P) from the resource (R)

When solving the first task, the lifting vehicle "L" is transported to the place of acceptance (storage) of the packaging "P" and captures it, forming a two-component flow "LP". It moves to the transport vehicle "T" and forms a three-component flow "TLP", the purpose of which is the transshipment of the packaging "P" from the lifting vehicle "L" to the transport vehicle "T". After that, the lifting vehicle "L" returns to the place of storage, and the newly formed two-component flow "TP" moves to the place of acceptance (storage) of the resource "R", transforming into a three-component flow "TPR". After unloading the packaging "P" (e.g., by means of a lifting vehicle "L" – it is not shown in Fig. 3) the transportation vehicle "T" returns to the storage location. Then the resource "R" is packed, forming a two-component flow (or rather, stock) "PR". The solution of the problem "separation of packaging from the resource" (Fig. 4) can be modeled in a similar way, carried out according to the algorithm: stream "L" to component "PR" → stream "LPR" to component "T" → stream TLPR → stream "L" and stream "TPR" → stream (stock) "PR" and stream "T" → stream (stock) "L" and stream (stock) "P".

3. When managing integrated logistic flows, different variants of movement (transportation and/or movement) of control components are possible. These options can be justified on the basis of such qualitative attributes and dichotomies as "state of component '1' and 'state of component '2": passive (symbol "0", waiting) and active (symbol "1", moving). The binary matrix created on the basis of these attributes and dichotomies includes the following blocks:

– "A": objects 1 and 2 are waiting (code "000");
– "B": object 1 moves either towards object 2 (code "010") or away from object 2 (code "011");
– "C": object 2 is moving either toward object 1 (code "100") or away from object 1 (code "101");
– "D": objects 1 and 2 move either towards each other (code "110") or away from each other (code "111").

This matrix also considers the directions of movement of components "1" and "2": towards or away from the object. For example, the code of a two-component flow like "T1L2" (code "1100") means that in the first variant the transport vehicle "T" moves towards the lifting vehicle "L" (block "B"), in the second variant vice versa – the lifting vehicle "L" moves towards the transport vehicle "T" (block "C"), and in the third variant they move towards or away from each other (block "D").

4. The information of the table can be supplemented with information about the number of jets of the resource flow "N" (increasing (symbol "0") or decreasing (symbol "1"), their quality "Q" (homogeneous (symbol "0") and heterogeneous (symbol "1"), as well as about the model of the flow, which includes these jets. The basic types of this model can be justified on the basis of the following qualitative attributes and dichotomies:

– “resource stream state”: not moving (symbol “0”) and moving (symbol “1”);

– “resource flow stream state”: not moving (symbol “0”) and moving (symbol “1”).

The combined use of these attributes and dichotomies allows us to identify such types of the sought model as stationary (code “00”), mobile (code “01”), static (code “10”) and dynamic (code “11”).

The above material allows us to digitize integrated logistics flows, i.e. to assign logically linked codes to them, considering the variants of their movement (transportation and/or movement) (Table 3).

Table 3

Codes for integrated logistics flow variants

<table>
<tr><th rowspan="3">Number of components</th><th colspan="10">Structure of the code</th></tr>
<tr><th colspan="3">Table 2</th><th colspan="4">Blocks</th><th>Model</th><th>–</th><th>–</th></tr>
<tr><th>Cipher</th><th>Code</th><th>Type</th><th>A</th><th>B</th><th>C</th><th>D</th><th>–</th><th>N</th><th>Q</th></tr>
<tr><td rowspan="4">One component</td><td>R</td><td>0001</td><td rowspan="4">–</td><td rowspan="4">–</td><td rowspan="4">–</td><td rowspan="4">–</td><td rowspan="4">–</td><td rowspan="4">–</td><td rowspan="4">–</td><td rowspan="4">–</td></tr>
<tr><td>P</td><td>0010</td></tr>
<tr><td>L</td><td>0100</td></tr>
<tr><td>T</td><td>1000</td></tr>
<tr><td rowspan="6">Two components</td><td>P1R2</td><td>0011</td><td rowspan="6">000</td><td rowspan="6">000</td><td rowspan="6">010 or 011</td><td rowspan="6">100 or 101</td><td rowspan="6">110 or 111</td><td rowspan="6">00, 01,10 or 11</td><td rowspan="6">0 or 1</td><td rowspan="6">0 or 1</td></tr>
<tr><td>L1R2</td><td>0101</td></tr>
<tr><td>L1P2</td><td>0110</td></tr>
<tr><td>T1R2</td><td>1001</td></tr>
<tr><td>T1P2</td><td>1010</td></tr>
<tr><td>T1L2</td><td>1100</td></tr>
<tr><td rowspan="16">Three components</td><td>(LP)1R2</td><td rowspan="4">0111</td><td>000</td><td rowspan="16">000</td><td rowspan="16">010 or 011</td><td rowspan="16">100 or 101</td><td rowspan="16">110 or 111</td><td rowspan="16">00, 01,10 or 11</td><td rowspan="16">0 or 1</td><td rowspan="16">0 or 1</td></tr>
<tr><td>(LR)1P2</td><td>001</td></tr>
<tr><td>(PR)1L2</td><td>010</td></tr>
<tr><td>LPR</td><td>011</td></tr>
<tr><td>(TP)1R2</td><td rowspan="4">1011</td><td>000</td></tr>
<tr><td>(TR)1P2</td><td>001</td></tr>
<tr><td>(PR)1T2</td><td>010</td></tr>
<tr><td>TPR</td><td>011</td></tr>
<tr><td>(TL)1R2</td><td rowspan="4">1101</td><td>000</td></tr>
<tr><td>(TR)1L2</td><td>001</td></tr>
<tr><td>(LR)1T2</td><td>010</td></tr>
<tr><td>TLR</td><td>011</td></tr>
<tr><td>(TL)1P2</td><td rowspan="4">1110</td><td>000</td></tr>
<tr><td>(TP)1L2</td><td>001</td></tr>
<tr><td>(LP)1T2</td><td>010</td></tr>
<tr><td>TLP</td><td>011</td></tr>
</table>

End of table 3

Number of components	Structure of the code									
	Table 2			Blocks				Model	–	–
	Cipher	Code	Type	A	B	C	D	–	N	Q
Four components	(TL)1(PR)2	1111	000	000	010 or 011	100 or 101	110 or 111	00, 01,10 or 11	0 or 1	0 or 1
	(TP)1(LR)2		001							
	(TR)1(LP)2		010							
	(TLP)1(R)2		011							
	(TPR)1(L)2		100							
	(LPR)1(T)2		101							
	(TLR)1(P)2		110							
	TLPR		111							

Compiled by the authors based on the research materials

The information presented in the table allows us to draw the following conclusions:

1. Classification of logistic flows is based on such qualitative attributes as "type of control component", "variant of flow component movement", "direction of flow component movement", "flow model", "number of flow jets" and "quality of flow jets". Based on these, a 14-character binary code of the integrated flow can be created. For example, the code "0111.010.100.11.0.1" using the table means "an integrated three-component logistic flow including a pick-up vehicle, a package, and a resource, in which the pick-up vehicle moves to the packaged resource using a dynamic model with an increasing number of heterogeneous jets".

2. The presented codes are used in the prototype development phase of a digital twin of business system control in order to:

– gain a systemic view of the actors, objects, components, elements and the interrelationships between them;

– create an idea of the possibilities of their structuring, formalization, identification, digitalization and modeling of the business system with the help of information technologies and computer support;

– develop a technical task for executors to create instances and aggregates of the digital twin of business system management, in which these subjects, objects, components, elements and interrelations between them will be digitized by other methods and codes;

– justify the timely transition from one set of subjects, objects, components, elements and interrelationships between them to another due to the replacement of classification attributes and dichotomies with more relevant attributes and dichotomies, which allows the business system to be reformatted.

3. The number of management components and classification attributes of integrated logistics flows can be supplemented if necessary. However, the solution to the more complex problem of digitalization and modeling of business system management objects can be obtained exclusively with the help of information technology and computer support.

4. A more complex task of digitalization and modeling arises in the case of the study of business systems of various types: channels, chains, fronts, echelons, and networks, in which integrated logistics flows are one of the main management objects. This task cannot be solved with the help of the currently prevailing subjective research methods, since business systems cannot be attributed to physical objects uniquely structured into subjects, objects, components, elements and interrelationships between them.

CONCLUSION

The contribution of the results of this study to theory lies in the development of a matrix approach to the digitalization of non-physical subjects, objects, components of management, and the interrelationships between them, based on descriptor and facet methods of qualitative research, allowing flexible response to changes in the internal and external environment of business systems of various types in the context of their global competition.

The contribution to practice is due to the possibility of creating prototypes of digital twins of integrated logistics flow management and business systems, on the basis of which it is possible to develop technical specifications for the design of instances and aggregates of these digital twins, allowing to significantly reduce the lost profits of management subjects.

The results of the study are novel and need fruitful discussion. They include:

– identification of a set of qualitative attributes and dichotomies that allow to organize the terms of subjects, objects and components of business systems management;

– formation of the theory and methodology of creating prototypes of digital twins of integrated logistics flows and business systems management described mainly by qualitative characteristics and dichotomies;

– relevance of creating a methodology for manual coding of these objects at the stage of preparing technical specifications (including on the basis of computer programs, considering the fact that manual and machine codes do not coincide with each other);

– methods of harmonization of parameters and characteristics of digital doubles of different types, etc.

In the present study the following results having signs of scientific novelty have been obtained:

– on the basis of the system approach the variants of integration of subjects and objects of business system management are substantiated;

– an end-to-end classification of enterprises and relations between them, management objects, processes and logistics operations was developed for the purpose of digitalization of integrated logistics flows and business systems of different types;

– variants of these flows are defined and digitized, and theoretical and methodological prerequisites for modeling these flows in various management situations are created.

Further research is envisioned to establish a coherent theory and methodology for designing and improving digital twins of business chain management and move towards creating digital twins of more complex business systems such as fronts, echelons, and networks of management actors and objects, while ensuring the loyalty of end users of products and/or services, as well as their sustainability in a continuously increasing complex operating environment.

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