ORGANIZATIONAL AND TECHNOLOGICAL PROBLEMS OF INTELLIGENT INTERACTION OF ROAD AND SEA TRANSPORT

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Summary
This article is devoted to the issues and related problems of intelligent interaction of road and sea transport in the organization of multimodal international transportation.

Since, today, the bulk of transportation is carried out with the participation of two or more types of vehicles, a multimodal delivery scheme is in most cases the only possible one when sending goods to another country, as well as to achieve an optimal ratio of quality, price and time. However, there is a problem of inconsistency in the technological process, due to the lack of development of the information management system. The article deals with the main problems of vehicle interaction, shortcomings in the process of intellectual interaction of elements of the transportation process, and their impact on the organization of transportation in the context of a conditional enterprise. Insufficient attention is paid to resolving issues of interaction and eliminating the causes of its inefficiency, while any complex system, which is undoubtedly a transport and logistics system, taking into account the requirements and security conditions imposed on it, in order to optimize, automate processes and smoothly organize work and interaction between individual elements of the system, it is necessary to detailed ordering and systematization of operations and actions that occur in the processes of this system. The mainlimiting factor for successful interaction is the lack of an intelligent management model in the organization of the transport process.

Key words: intelligent model, information flow, consistency, multimodal transportation, transportation process, system.

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1. Introduction

The complexity of organizing international transportation is reduced to the fact that the use of only one type of transport is most often insufficient to deliver goods from the point of departure to the destination, and the transport of goods by road and sea is a common delivery scheme in international traffic. Based on this, the issues of transport logisticsrelated to the interaction between different modes of transport, one way or another, constantly arise in the production process of transport companies.

Considering that in order to ensure the effective provision of logistics services, transport companies must take into account all the nuances that are associated with the problems that inevitably arise after the transfer of cargo, during delivery, from one mode of transport to another, it is necessary to consider the problems of interaction between road and sea transport in multimodal international transportation

The relevance of the research topic is beyond doubt, since transport is indeed the most important component of the state's business cycle, and effective interaction of all key elements of the transportation process requires not only the choice of optimal modes of transport, but also their consistency, depending on the specifics of the location of counterparties and the availability of appropriate infrastructure.

One way or another, the organization of the transport process and the formation of cargo supply chains is implemented through operational data exchange and information transfer between participants in the transport process, as well as operational management to meet the needs of the transport services market. In order to ensure a decent level of transport service quality, it is necessary to use information systems and software packages that allow for analysis, planning and support in making managerial decisions.

The purpose of the study is to introduce progressive principles of organization and management of transport processes in freight-forwarding activities based on intelligent information technologies, which will contribute to improving the quality of transport services.

Main research objectives:

– analysis of available methods and principles of organizing freight-forwarding activities at a conditional enterprise;

– the ability to reduce paper document flow and interpersonal communication by phone;

– improvement of methods of organization and management of information flow in the process of transport forwarding.

The object of research is an information control system and a system for managing the technology of transport processes in the provision of forwarding services.

2. Conditions for successful interaction between road and sea transport

Successful cooperation between different modes of transport is ensured by the consistency and coherence of operations on different modes of transport that are involved in the overall cargo transportation process.

In the course of analyzing the practice of the transportation process, it became clear that the interaction of various modes of transport depends on many conditions, including technical, technological, organizational and managerial ones *(Levin B.A. et al., 2015:56)*.

The technical side of the interaction problem is caused by the insufficient level of structural and capacity unification of all elements of different types of transport involved in multimodal transportation. This requires:

1) coordination of the through put and processing capacity at the junction lines followed by cargo flows, as well as individual devices in the nodes, for example, the capacity of portside motor transport terminals and berths, the adaptability of equipment to transshipment of goods from cars to ships and back, the capacity of warehouses, the capacity of transshipment equipment, etc. should be taken into account;

2) Parameters of a rolling stock of interacting modes of transport should be compared. In particular, they must correspond to the carrying capacity and specialization of the vessel and vehicles;

3) The availability of a reliable and convenient telecommunication system and efficient means of communication, primarily between the operational device that provides the transportation process in transport hubs and directly on the lines adjacent to the nodes.

The complexity of the technological aspect of the problem lies in the need to subordinate cargo handling operations in transport hubs to a single order, without which it is not possible to quickly and efficiently transfer goods from one mode of transport to another. The success of resolving this issue also depends on the level of information management development at the enterprise, since it is necessary to ensure careful coordination of industry technological processes among themselves.

With regard to the organizational aspect of the transport process, the problem of interaction is resolved by the adoption of a unified system for operational planning of current work and comparison of traffic schedules of transport units (Bubnova G.V. et al. 2017:93). The unity of the operational planning system can be achieved by establishing unified forms of daily and shift plans on all elements of the node, introducing ая single time for the start and end of work shifts and observing the established procedure for exchanging the necessary information about the planned movement of traffic flows.

The management system, or rather operational decision-making, also has a significant impact on the process and results of operational work at the junctions of interaction and during the entire transportation process. The productivity of this command depends not only on compliance with all the above conditions, but also on the effectiveness of the existing information structure in the enterprise. Based on the experience of the company's management, it follows that the formation of a so-called unified management center, designed to make effective management decisions, based on up-to-date information obtained in real time, gives positive results.

A significant improvement in the quality of interaction between different modes of transport, according to all these criteria, can be achieved by implementing an intelligent model of the quality control system for the transportation process.

3. Organizational and technological problems of interaction between road and sea transport at the enterprise

One of the weak points of the transport process in the organization of multimodal transport is the junction between road and other modes of transport. This is especially true when transporting export cargo through seaports and land border crossings.

The main reason for this situation is the irregular and uncoordinated supply of cargo to ports and transshipment points, as well as the insufficient development and use of existing processing capacities for transshipment of cargo to other modes of transport. Irregular and uncoordinated delivery of cargo to transshipment points occurs due to the lack of a single transport conveyor, disunity of types of ownership and management systems of transport and other entities involved in the technological process of transportation.

In order to develop measures that can significantly improve the quality of interaction between road and sea transport, was analyzed all the circumstances that contribute to delays of vehicles approaching to seaports at the conditional enterprise "X", after which they were grouped and hierarchized with respect to the main causes, as well as factors of influence of level 1 and 2. The first level includes the most significant factors that directly affect the main causes, and the second – factors that affect the factors of level 1. The results of the study are shown in the Table 1.

Table 1

Pins and factors influencing the quality of interaction between road and sea transport at the enterprise

Causes of problems of interaction between road and sea transport	Contributing factors	
	1 level	2 level
1. Uncoordinated supply of cars and ships	1.1. Lack of information about the approach of vessels	-freight of vessels by foreign buyers; -failure to provide data when loading by the sender
	1.2. Lack of control over the agreed supply of cars and ships	- there are no calendar schedules for the agreed supply of cars to the ship's arrival.
	1.3.Failure to comply with the "just-in-time delivery" principle	- lack of logistics principles for managing cargo flow promotion
2. Non-development of the declared volume of transshipment by the port	2.1. Insufficient processing capacity of loading and unloading mechanisms (LUM)	- equipment breakdowns; - insufficient number of LUM
	2.2. Lack of available storage areas	- lack of ships; - insufficient storage capacity
3. Uneven arrival of cargo in cars at the port station	3.1. Loading in excess of the request without taking into account the port's transshipment capabilities	-the consequences of the lack of an intelligent information flow distribution structure
	3.2. Uneven shipment	- violation of shipment schedules
4. Force majeure	4.1. Storm	- Weather conditions
	4.2. strong wind	
	4.3. ice conditions	

Based on this table, a diagram is constructed that clearly demonstrates the hierarchy and interdependence of the entire complex of factors that contribute to vehicle delays on approaches to seaports. The Ishikawa causal diagram is shown in Figure 1.

In order to determine the significance of each of the above factors for further research, we use the method of expert assessments. The results of the evaluation are summarized in Table 2.

As can be seen from the research materials, a significant proportion of the reasons associated with uncoordinated supply of cars and ships, as well as uneven (condensed) supply of cargo to ports, is due to the following factors.

Table 2

Percentage of reasons related to car delays

Main reasons for vehicle delays	Specific weight, %
1. Uncoordinated supply of vehicles and vessels	40
2. Uneven arrival of cargo at the station	35
3. Failure to meet the planned standards of port overload	20
4. Force majeure (bad weather)	5

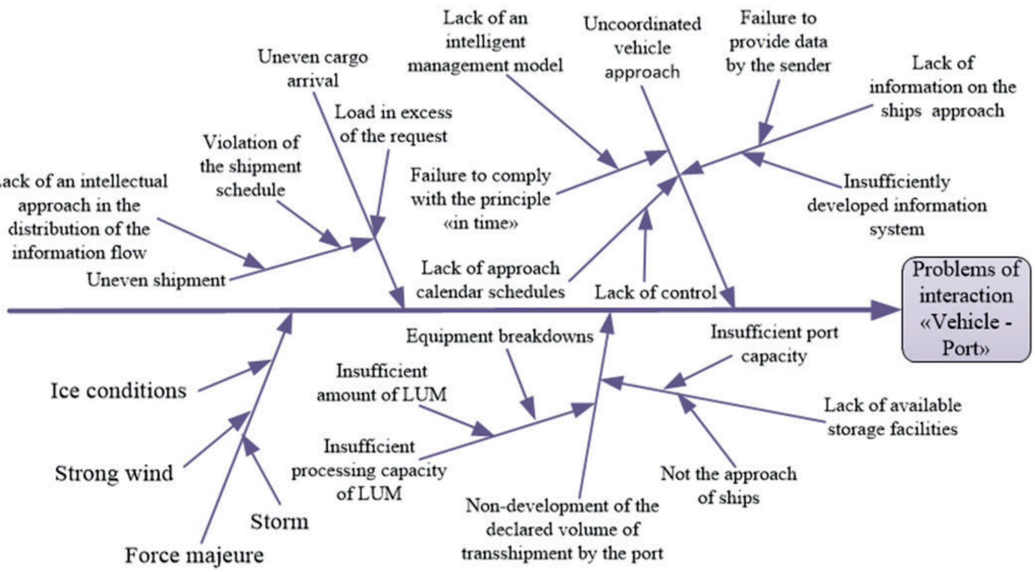

Figure 1. Isakov's causal diagram of «Vehicle-port» interaction problems

The first factor. The effectiveness of multimodal transport primarily depends on successful interaction at the «Car – Port» level. It is necessary to isolate yourself from the stereotype that the interaction of road and sea transport begins and ends in the port. A seaport is a fixed infrastructure element in a given transport logistics chain with a clearly defined strategic goal – transshipment of cargo from road transport to sea and back – and by definition should not and cannot engage in interaction between road and sea transport. Currently, the «car-port» interaction can function effectively only with the creation of a new technology for the interaction of modes of transport.

The second factor. The shipper is not interested in the speedy transshipment of the cargo. The current practice of concluding international sales contracts between sellers and foreign buyers on the terms of FOB (Free on board) does not contribute to the organization of a clear and well-coordinated organization of cargo transshipment from road to sea transport. In accordance with this condition, the ship's freight is carried out by a foreign buyer, who plans to bring the ship in such a way that the cargo is already in place.

More progressive is the CIF delivery (Coast, Insurance, Freight). In this case, the seller, in accordance with the contract of sale, is responsible for its delivery on a "just-in-time" basis to the port of destination.

The difference in the organization of information flow at the stage of transportation under the terms of delivery of FOB and CIF is shown in Figure 2.

The organization of the material and information flow in the case of mixed road and water cargo transportation under FOB conditions also determines the system of preliminary and accurate information on the arrival of a vessel at the seaport at the present time at the enterprise. The date of arrival of the vessel at the seaport is determined by the foreign charterer on the basis of information from the supplier about the shipment of the cargo and the date of arrival of its transshipment point. This information is transmitted through a representative of the shipper to the port that is the recipient of the cargo in the territory of the country of departure. Accurate

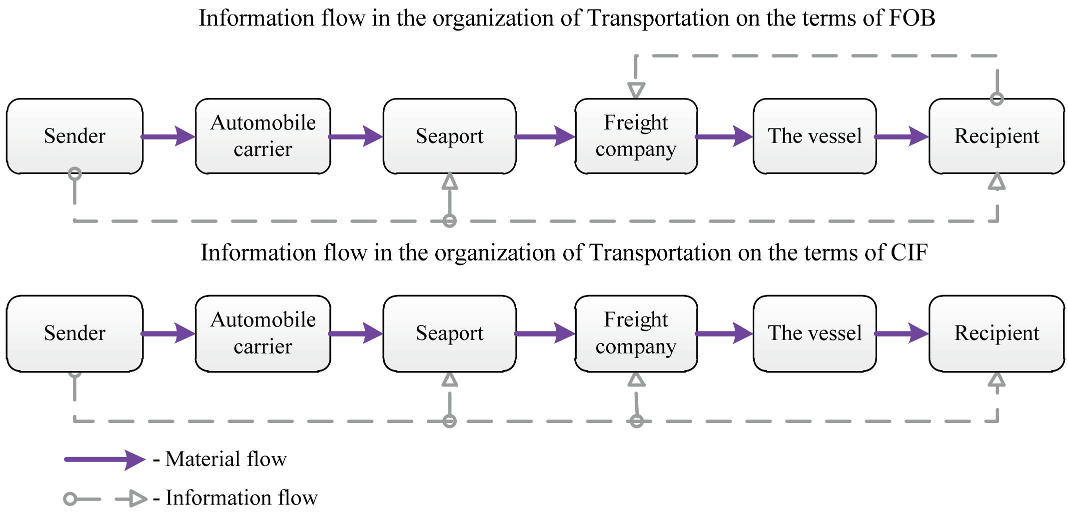

Figure 2. Organization of information flow under different delivery conditions

information about the arrival of the vessel comes from the captain of the vessel, who, through the chief dispatcher of the port, requests permission to enter. And the port station receives preliminary and accurate information already from the port.

Figure 3A shows the current flow pattern of preliminary information about the approach of ships to the seaport, and proceeding from this, we can identify the third factor contributing to the problems of compatibility of road and sea transport at the enterprise - the level of awareness of enterprise "X" about the approach of ships does not correspond to the realities of today and should be improved in terms of timely receipt, as well as the possibility of using it to coordinate the supply of cars and vessels. The use of currently obtained information may not be effective for the following reasons. First, the lack of financial responsibility for the quality of information does not encourage its reliability. Secondly, obtaining information in the last place deprives the car carrier of the ability to manage the supply of vehicles on equal rights with the port based on their own and joint interests.

And third, the presence of even reliable information in the absence of an intelligent information structure within the enterprise "X", which could use it to organize the delivery of exactly the cargo that the ship is suitable for, makes the information useless.

Thus, one of the main reasons for the downtime of cars in the port is the lack of coordination on the supply of vehicles with exactly the cargo that the ship arriving at the port plans to pick up. Cars are processed by the port not in the order of receipt, but for a specific vessel, therefore it is necessary to organize the supply of goods necessary for the loaded vessel, which can be significantly facilitated by the introduction of an intelligent information exchange system between participants in the transportation process in total using innovative telematics tools.

4. Measures to implement ITS in the enterprise

It is obvious that the existing model of managing transport and logistics processes of enterprise "X" requires serious adjustments in favor of using intelligent methods of managing the transport process and information flow. In this regard, the need for a new approach to the organization of multimodal transport is determined by the following provisions that follow from the analysis of the current situation:

1. When organizing multimodal transport, it is necessary to move to the «Road – sea transport» level, while simultaneously improving the forms of interaction at the «station – port» level.

2. When entering into international sales contracts under the terms of FOB delivery, it is not advisable to rely on the shipper's interest in the speedy transshipment of the cargo, since he does not affect this process.

3. It is necessary to change the system of informing the road carrier about the approach of sea vessels, while creating a telematics structure that can use this information. It is mandatory to create a highly efficient information environment at the level of the route and management of transport processes in mixed traffic, namely, the organization of control over transport and cargo units along the entire route and informing key participants in the transportation process about this;

4. Orientation in the organization of multimodal transportation to the seaport as a representative of maritime transport is unpromising, since it is not a carrier and, moreover, its interests are much closer to the interests of shipowners than to a forwarding company.

Based on this, the most effective reserve for improving the quality of interaction between road and sea transport is the application of an intelligent approach to managing multimodal transport, to achieve which the following organizational and technological measures can be identified:

First. It is necessary to organize planning for the supply of motor vehicles for specific vessels. To do this, we need to change the system of information interaction between the seller, port and carrier at the enterprise level. The scheme of the proposed information interaction is shown in Figure 3 B.

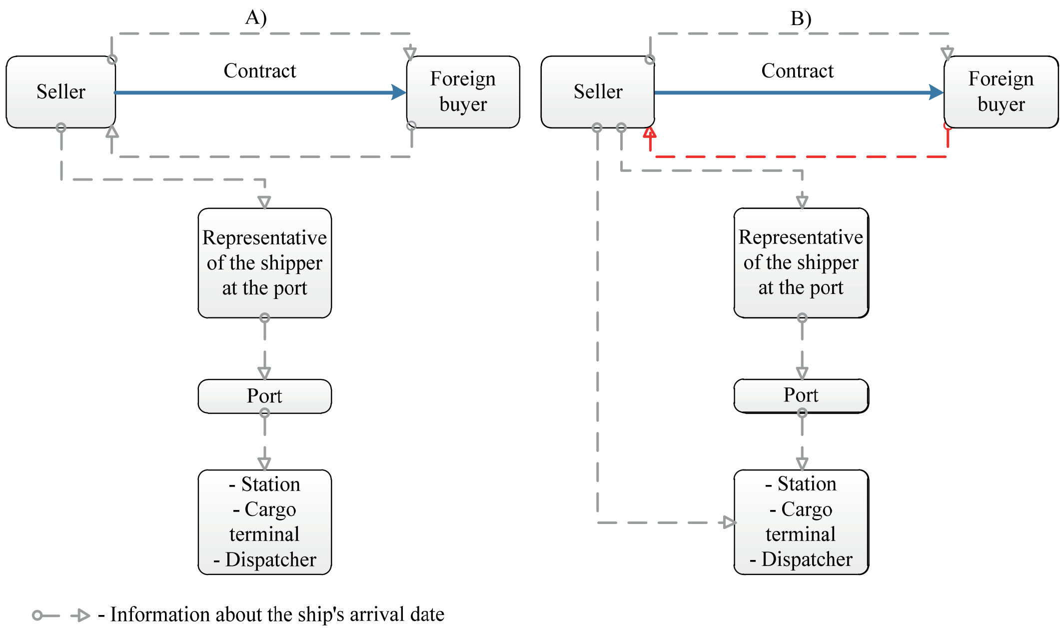

Figure 3. Flow diagram of information about the arrival of ships:
A – the current flow diagram of the information flow; B – the proposed flow diagram of the information flow

Such an organization of information interaction will allow the motor carrier to manage the supply of vehicles and eliminate their accumulation due to inconsistency in the arrival of rolling stock of an adjacent type of transport.

Second. As noted above, it is advisable to introduce intelligent logistics management methods to control complex interaction processes at the junctions of the transport corridor and make effective decisions in the field of transportation process based on high-quality information support.

The task of creating a rational, economically feasible and mutually beneficial structure for managing cargo flows in multimodal transportation for all participants in transportation should be solved in the direction of forming a transportation management system that provides enhanced interaction at the level of «road carrier-sea transport» and includes as subsystems corporate logistics centers created on the basis of portside highways-branches of the enterprise "X". In turn, the basis of the system should be a regional transport and logistics center, the purpose of which is to increase the volume of transit cargo transportation through sections of international transport corridors by improving the level of organization of export-import and domestic transportation in mixed road and water transport.

5. Development of an adaptive model of hardware control in the interaction of road and sea modes of transport

A transportation management system that provides enhanced interaction at the level of road carriers and sea transport, including as subsystems corporate logistics centers created on the basis of portside highways of enterprise branches X should be formed on the basis of intelligent concepts of dispatching management of the entire cycle of the transportation process. To do this, it is necessary to develop intelligent concepts of the formed processes of the dispatching center. In this article, we propose the formation of a computational apparatus based on neural networks *(Gallant S.l., 1993:98)*. This approach will make it possible to form an adaptive model of hardware management of the «sender – carrier – port-recipient» communication system.

The requirement of adaptation in the process of performing a given task, without prior training in a specific environment, is a fundamental distinguishing requirement of the problem statement of this adaptation model *(Gubin S.V. et at., 2009:24)*.

To implement an adaptive management system (hereinafter referred to as the management system), we will use a topology with two newly proposed components – the decision maker component and the teacher component. The main decisive component will be the decision maker. It receives input information about the current state of the environment, the current state of the object, and outputs control actions. The most important part of the system is the training component, which is the dispatching control center, which operates on the basis of an intelligent concept of monitoring the transport process. In turn, the transportation process itself is an object of management. It is in the dispatcher control center that the state of the environment is evaluated from the point of view of changing behavior tactics, and also changed rules of behavior of the entire system are formed. The input of this component is provided with information about the state of the environment processed by the sensor component.

The management system (hereinafter referred to as MS) must maximize the Efficiency coefficient (EC). EC is used to identify a change in the behavior strategy that has improved or worsened the overall performance score. This EC is the main source of information for building an effective self-learning scheme. In this case, EC is calculated based on processing information about the external environment, the object, and the nature of the object's interaction with the environment.

The entire system as a whole is built on a single neural network of the developed topology. The topology is shown structurallyin Figure 4:

We introduce the following notation:

t – time (control cycle);

SMP a (t) – rules of self-study for each teacher;

SMP b (t) – decision maker component management rules;

EC (t) – Efficiency coefficient per iteration;

a (t) – the effect of the control system on the control cycle t, where $a(t) \in A\ \{a1, a2...an\}$;

s (t) – the state of the object on the control cycle t, where $s(t) \in S\ \{s1, s2...sn\}$;

A – the impact space of the MS;

S – the object's states space;

AP – adaptation parameter – an element of the decision maker's management rules that is changed to adapt the management rules;

τ (EC) – volume of the change history EC;

τ (AP) – the amount of the AP change history.

We will also introduce several definitions related to time:

Iteration – the completed object management cycle, i.e. the cycle between the impact of the external environment and the response of the control system to it.

Critical time τ – the time set by the developer, during which the system must restore the specified efficiency coefficient, otherwise the system does not complete the task.

Additional training period τ*n* – the time it takes for the system to reach it again if the set value of the efficiency coefficient is lost. Defined as:

$$\tau n \le \tau 3$$

It is proposed to use the efficiency coefficient λ:

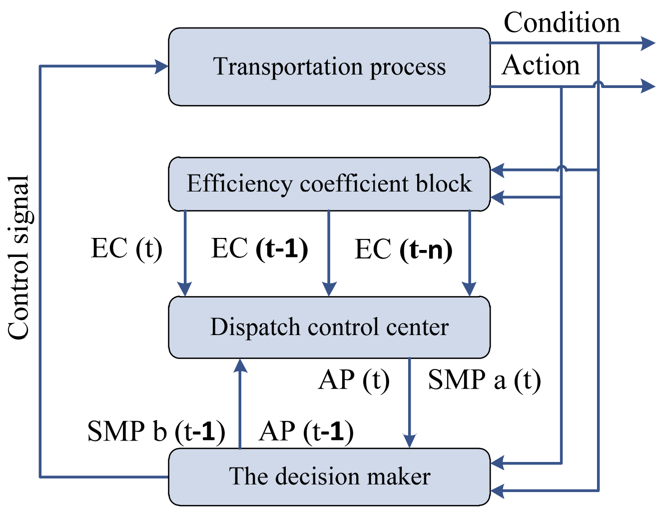

Figure 4. Internal Teacher Topology

$$\lambda i = \frac{Ai}{Ei}$$

where i is the number of the time quantum (iteration, one completed control cycle) for which we calculate the coefficient,

Ai – a dimensionless indicator of the useful activity produced by the object,

Ei – a dimensionless indicator of resources spent.

EC is written in a generalized form. It is calculated based on processing information about the external environment, the object, and the nature of the object's interaction with the environment. When using the developed topology in different systems, the efficiency coefficient should be calculated differently. EC is calculated in a separate component and manages the self-learning process.

The Efficiency coefficient block stores the change history (ECB). This is necessary to calculate the dynamics of EC changes. For each of several periods, the average EC values are calculated and compared for neighboring periods. We are interested in fuzzy values of dynamics: EC decreased; EC has grown; EC has not changed.

Then these indicators are sent to the teacher's input, which, according to the rules of self-study, determines whether a modification of the management rules is necessary and modifies them if necessary. The length of the history, as well as the parameters for calculating the average EC, must be modifiable, and adjusted depending on the environment and object. During the operation of the control system, it is desirable to meet the following conditions:

$$\lambda(t) \le \lambda(t+1) \ldots \le \lambda(t+n)$$

Thus, due to the self-learning policy, EC growth should be ensured EC during the operation of the system. But the algorithm does not guarantee the growth of reinforcement.

Teacher inputs – changes in the efficiency coefficient for the last time period (or for the last few) and changes in the main parameters of the environment (one or more). Teacher output – modified control rules passed to the solver. The teacher is implemented as a traditional non-adaptive task force using a neuralnetwork that implements a fuzzy function. The fuzzy function takes as input the EC dynamics, the object state, and changes in adaptive parameters of control rules. In this example, the environment is ordered, but cannot be predicted by a mobile robot while moving. The robot adapts to the nature of the environment, being able to work out a completely different environment (for example, a completely chaotic pile of barriers), while spending limited resources.

The internal device of the teacher is a layer-by-layer fully connected neural network with 1hidden layer. Teacher inputs – changes in EC for the last time period (or for the last few), plus adaptation parameters (one or more) for the previous time period. The teacher outputs the modified AP values (Figure 5). The teacher implements the SMP self -study policy. To implement the principle of self-learning, we introduce a general form of functions that calculate AP and EC:

$$ECt = F\left(a_t, s_t, EC_t, AP_{t-1}, \ldots\right),$$
$$APt = Z\left(APt-1, ESt, ESt-1, \ldots\right),$$

Note that F is not an inverse function of Z and vice versa, that is, there is a decomposition of functions, thus, the politicians the SMP_a and $SMP_{B\ policies}$ depend on S_t, A_t, EC, AP, and possibly other parameters.

The rules of the teacher's self-study change the AP and are formulated as follows:

if the EC value has decreased, then we change AP in the opposite direction from the previous changes.

if the value has increased, then we continue to change the AP in the direction from the previous changes.

if the value has not changed, then depending on EC, we either leave the current rules (if EC is satisfied), or randomly change the applied rule.

Let's present the rules for changing AP in the form of products, in the case of one adaptation parameter of the system and :

$$\downarrow EC(t)S\left(\downarrow AP(t-1)\right)S\left(\downarrow EC(t-1)\right)\Rightarrow\uparrow AP(t),$$
$$\downarrow EC(t)S\left(\downarrow AP(t-1)\right)S\left(\downarrow EC(t-1)v\uparrow EC(t-1)\Rightarrow\uparrow AP(t),etc.\right.$$

The step of changing AP should be reduced depending on the relative magnitude of the EC change in order to maximize it when implementing the search for the global maximum of EC.

When developing an application implementation, it is necessary to analyze the problem and specify the rules of self-learning for the needs of a particular enterprise. The system must adapt to changes in the environment. The environment behaves non-deterministically. However, despite its nondeterminism, it is necessary to distinguish such classes of environmental impacts that the system will work out.

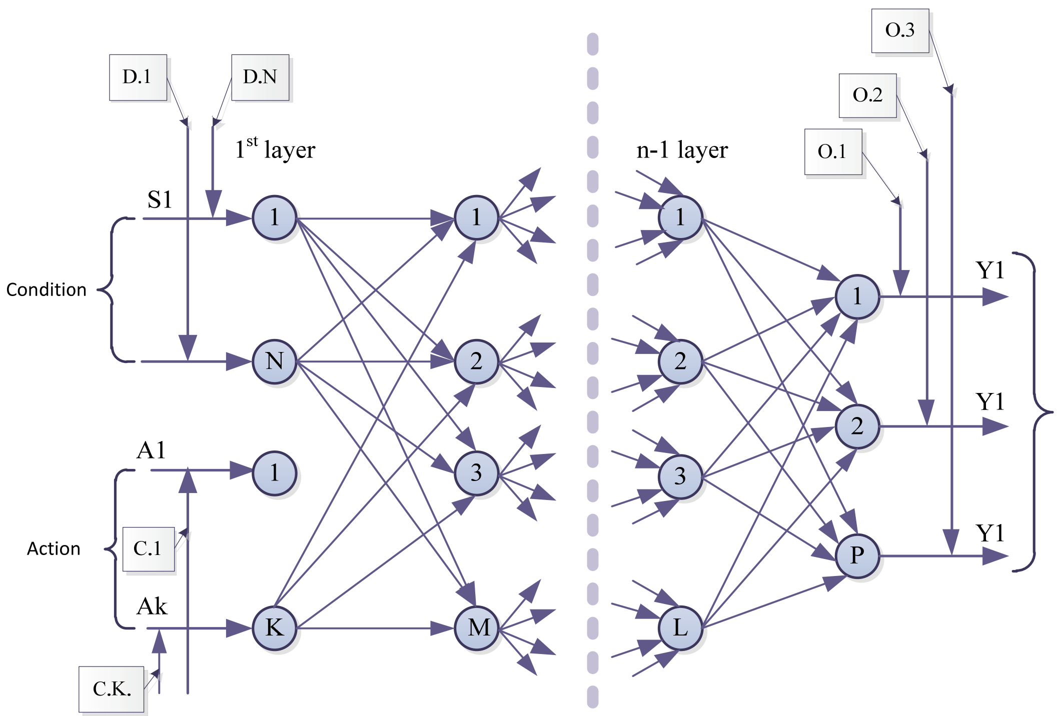

Figure 5. Teacher in neural network implementation

The managed object has several AP, effectively managing all parameters under any environmental influences, we can say that the control is effective in general. But this kind of management is generally impossible. Thus, it is necessary to select such AP objects that need to be managed for effective management in such environmental impact classes, which we discussed earlier. Then, the initial task will include the following items:

– allocation of system-critical classes for the impact of a non-deterministic environment on an object.

– selection of AP objects that the control System will adaptively manage, implementing the task and working out the effects of the environment.

Next, it is necessary to formulate the rules for managing the object (the necessary AP of the object) without adaptation. Rules (predicates, fuzzy rules, etc.) will describe the control of the object by the Solver without adaptation. The next step will be to finalize the management rules (management policies):

– it is necessary to select the components of management rules that will adapt adaptively to the environment.

– it is necessary to provide for such behavior of the decision maker and the proposed set of rules, when some rules are added or removed (i.e., when adapting, some rules may appear or disappear).

The above is necessary in order to formulate a self-learning policy in accordance with the needs of the enterprise. The policy should be that the nondeterministic impact of the environment affects the management rules themselves. In this case:

– environmental impact that does not have the character of a radical novelty should be worked out by the management rules without changing them.

– environmental impacts that are new and unknown to the management system should lead to adjustments to the set of management rules (changes, additions, and deletions of rules).

At the end, it is necessary to work out in detail all the nuances of the rules of self-study. The previously identified patterns of environmental changes, as well as the methods of changing rules developed to work them out, require more clear instructions for self-learning, focused on the tasks set at each specific enterprise. At the output of the self-learning rules, we must have parameters (all necessary) for changing the management rules. At the input – the dynamics of changes in reinforcement (efficiency coefficient). Thus, we`ll get two sets of rules-modifiable control rules and self-study rules.

6. Conclusions

The issue of interaction between different modes of transport in multimodal transport is one of the most important today, since the insufficient level of consistency complicates the process of commodity exchange, and also significantly reduces the efficiency of using rolling stock of different modes of transport. The lack of consistency between the participants in the transport process leads to downtime of heavy vehicles in port terminals, which can be avoided by introducing an intelligent model for managing the transport and information flow at the enterprise.

To implement the functions of intelligent management and control, была проведена оценка the existing information management system at the enterprise was evaluated, and the reasons and factors contributing to the deterioration of the quality of interaction between road and sea transport were identified. Based on this, measures were proposed to improve the level of efficiency of logistics and transport management.

Using the achievements of scientific and technological progress in the field of informatics and digital technologies, it is possible to implement the methodology of logistics management by:

– Digitalization of logistics management processes, namely: by introducing digital and computer-based management tools into the processes;

– Use of innovative software and information systems that automatically perform the functions of planning, forecasting and making effective management decisions.

– Development and assignment of new data transmission standards;

– Use of modern equipment and software for receiving and transmitting digital information.

These results will make it possible to provide high-quality control over all stages of the transportation process, which will allow us to quickly identify problem areas that lead to inefficiency in the existing operational process management schemes at the enterprise. In addition, these achievements and an understanding of the essence of intelligent transport systems provide the necessary information and requirements for the development of new, more efficient ways of organizing and managing traffic flows in the future.

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