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РОЗРОБКА ПРОЦЕДУРИ ФОРМУВАННЯ ПОЇЗДІВ НА КОНТРЕЙЛЕРНИХ ТЕРМІНАЛАХ НА ОСНОВІ ТЕОРІЇ МНОЖИН

DEVELOPMENT OF A TRAIN FORMATION PROCEDURE AT CONTRAILER TERMINALS BASED ON SET THEORY

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The article presents proposals for developing a train formation procedure at contariler terminals based on set theory. Considering the irregularity and variability of transport flows, their value can be determined through statistical analysis and forecasting of cargo flow growth in recent years. In organizing transportation, elements of combinatorics, probability theory, random flow theory, and other mathematical methods are applied. To compose a contariler train based on set theory, it is necessary to determine the required number of transport vehicles.

Vehicles for assembling a contariler train can be in various directions and quantities, either interconnected or independent of each other. Due to the probability of an event differing by a number of parameters, it can be considered as a product of events based on set theory. The computational process is a random process that is represented by a non-decreasing, integer-valued computational function [1].

The phenomenon is complicated by the fact that during a flow event, different quantities of compositional units can arrive at the station simultaneously. To simplify the process of analyzing this phenomenon through the theory of random flows, it is recommended to consider it as a superposition of flows from various sets. From a theoretical standpoint, the most important characteristic of the flow is the average number of events per unit of time within a certain time interval, i.e., its intensity. In the case of a stationary flow, this intensity remains constant over time [2].

In analyzing the volume of train car flows in railway transport, elements of mathematical combinatorics and principles of set theory can be applied. These principles are used in the occurrence of events that are either interconnected or independent of each other. In this case, the vehicles assembled at the terminal are designated as event A, and the railway cars required for these vehicles are designated as event B. The conditions for the occurrence of events A and B are then examined [3].

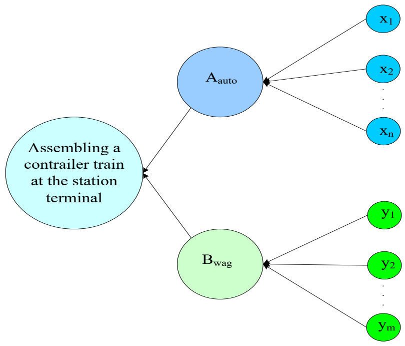

Figure 1. Sequential diagram for assembling a contrailer train

In this case: Event A consists of $x_1, x_2 ... x_n$ elements and event B consists of $y_1, y_2 ... y_m$ elements, denoted as $A = \{x_1, x_2 ... x_n\}$ and $B = \{y_1, y_2 ... y_m\}$ respectively.

There may be a pre-assembled quantity a_0 of available vehicles at the contariler terminal [4]. During the process of receiving a contariler train at the terminal, we denote the quantity of incoming motor vehicles as $a_{q.q}$ and the quantity of outgoing motor vehicles in the departing train composition as a_j. Using these expressions, it is necessary to calculate the value of the difference Δa that arises between arrival and departure. To calculate the number of vehicles Δa in the contariler terminal, the following expression can be introduced:

$$\Delta a = | a_{q.q} - a_j | , \qquad (1)$$

If $\Delta a > 0$ occurs, an excess motor vehicle remains in the contariler terminal, while in the case of $\Delta a < 0$, it is necessary to add motor vehicles from the contariler terminal to the rolling stock. Considering that the process of receiving and dispatching a train is continuous, the general form of the accumulated motor vehicle increments at the terminal can be expressed as follows:

$$\Delta a_1 + \Delta a_2 + ... + \Delta a_n = \sum_{i=1}^{n} \Delta a_i \, , \qquad (2)$$

This expression can be transformed into the following form by taking into account that $\Delta a = a_{q.q} - a_j$ is derived from expression (2) in the case of $\Delta a > 0$:

$$\Delta a_1 + \Delta a_2 + ... + \Delta a_n = (a^1_{q.q} - a^1_j) + (a^2_{q.q} - a^2_j) ... + ... (a^n_{q.q} - a^n_j) = (a^1_{q.q} + a^2_{q.q} + ... + a^n_{q.q}) - (a^1_j + a^2_j + ... + a^n_j) = \sum_{i=1}^{n} a^i_{q.q} - \sum_{i=1}^{n} a^i_j \qquad (3)$$

Here, the increment $\sum_{i=1}^{n} \Delta a_i$ is expressed, which occurs after the process of receiving and dispatching vehicles has taken place multiple times. That is, from expression (3), the following form of expression is derived:

$$\sum_{i=1}^{n} \Delta a_i = \sum_{i=1}^{n} a^i_{q.q} - \sum_{i=1}^{n} a^i_j \, , \qquad (4)$$

Taking into account the obtained expression (4), as well as the quantity a_0 of vehicles already accumulated at the terminal, and the minimum number of vehicles $\lambda^{avto}_{\min}$ required for the train composition, the following condition can be introduced for forming a new train:

$$a_0 + \sum_{i=1}^{n} \Delta a_i \geq \lambda^{avto}_{\min} \, , \qquad (5)$$

After the formation of an avtotransport surplus in the amount of a_i satisfying this condition, it will be possible to form a contariler train at the terminal. In addition, considering that when creating a new train, along with motor vehicles, there should also be the required number of railway cars, the number of cars can be expressed as follows:

$$b_0 + \sum_{j=1}^{m} \Delta b_j \geq \lambda_{avto}, \tag{6}$$

where: b_0 – number of railcars available at the terminal;

$\sum_{j=1}^{m} \Delta b_j$ – the number of empty wagons during the loading and unloading process.

If the sum of the number of wagons in expression (6) is sufficient for the value intended for transporting motor vehicles, then it is possible to form a new train. Otherwise, b_x quantity of empty railway cars will have to be delivered to the terminal for transportation.

In this process, that is, in case $b_0 + \sum_{j=1}^{m} \Delta b_j \leq \lambda_{vag.}$, the following equation is obtained by adding b_x to the expression:

$$b_0 + \sum_{j=1}^{m} \Delta b_j + b_x = \lambda_{vag}, \tag{7}$$

The expression for calculating the value of the quantity b_x using the substitution method from the given equation can be written in the following form:

$$b_x = \lambda_{vag} - (b_0 + \sum_{j=1}^{m} \Delta b_j), \tag{8}$$

Using the derived expression (8), the number of missing railway cars should be determined, and this quantity of empty cars should be brought to the terminal. By utilizing these expressions, the formation of a new contariler train through motor vehicles and railway cars assembled at the terminal prevents unnecessary waiting times.

The optimal value for a contariler train is considered to be when the total value of the assembled motor vehicles constitutes the maximum permissible amount of rolling stock for train formation, and there is a corresponding availability of railway cars matching this value. By using these methods to form a new contariler train with motor vehicles and railway cars assembled at the terminal, excessive waiting times are prevented.

[1] Boschian V. Dotoli M., Pia Fanti M., Iacobellis Go, W. Ukovich W. A metamodelling approach for performance evaluation of intermodal transportation networks. European Transport. 2020. Vol. 46. P. 100-113.

[2] Chang Zhu. A Novel two-stage heuristic for solving storage space allocation problems in rail–water intermodal contariler terminals. Symmetry. 2019. Vol. 11(10). 1229.

[3] Ziyoda Adilova, Diyor Boboyev, Navruz Axtamov. Mathematical model of fastening conditions in contariler transportation taking into account various conditions. Transport bulletin: 2024/9/30, 98-103.

[4] Boboev D.Sh., Mukhamedova Z.G. Development of international transportation on the basis of creating a system of contrailer transportation // Pedagog. Vol. 5 №4. 2022, 10-23 p.