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DEVELOPMENT OF RATIONAL RAIL NETWORK TOPOLOGY FOR HIGH-SPEED AND CONVENTIONAL TRAINS BASED ON BACTERIAL FORAGING OPTIMIZATION

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Implementation of projects on higher speeds of passenger trains on the world railways requires investigation into a balanced co-existence of high-speed and conventional traffic with consideration of rail network topology development. The solution to the problem is rather complicated and based on synthesis of investigation into the theory of traffic flows, transport geography, network development and transport economic theory [1-3].

The latest achievements in the field of network design problems [4-6] confirmed that macro characteristics of a complicated transport system are not formed on the base of central top-down hierarchical planning, but determined by self-organizing passenger flows based on demand for transportation. Artificial demand stimulation methods for passenger trains of technical and economic parameters which do not meet the transportation requirements lead to re-distribution of flows along the line with possible refusals from some categories of passengers to travel, which finally results to the whole transport system unprofitability. The above mentioned testifies that there is a need to make a further research into formalization of procedures to search for a rational rail network topology for high-speed and conventional train traffic.

In order to solve the problem, an entropy model to search for a rational passenger train flow distribution, which takes into account the rail network topology of high-speed and conventional traffic, has been formed. It is based on multi-agent optimization methods and demonstrates the performance of a rail passenger transportation system in terms of transport system development subject to demand for transportation.

The study proposes to use the concept of entropy because of isomorphism in systems for investigation into self-organization of train flow distribution; it allows researching and implementing connection between micro and macro levels in the passenger transportation system. On the base of the second law of thermodynamics, the rail passenger transportation system is presented as a closed physical system tending to a steady, equilibrium state, when uncertainty, measured as entropy, is maximal. The maximum entropy in the system makes it possible to find such a system status, which is characterized by spatial distribution within a passenger flow network, and, as a consequence, high-speed and conventional train flows, which in terms of probability is reminiscent of one possible for a real transport system considering patterns of collective behavior.

An entropy model has been proposed to formalize the high-speed train distribution process in the network. Unlike existing ones, the model helps simultaneously determine the rail passenger transportation topology and the most probable distribution of high-speed and conventional train flows in the network, which can occur in a real transport system, taking into account the patterns of passenger collective behavior. To solve the mathematical model the authors have used an optimization method based on Bacterial Foraging Optimization. While using the method of Bacterial Foraging Optimization the process, which makes it possible to consider the peculiarities of a multistage task of the train flow distribution within the rail network, namely, defining the network topology, distribution of passenger flows and train flows within the network, has been enhanced. The implementation of the mathematical model based on Bacterial Foraging Optimization will make it possible to theoretically substantiate the efficiency of existing and promising projects on higher speeds of passenger trains on the rail transport regarding adaptation of the network topology to transportation demand.

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