SIMULATION OF TRANSPORT INTERCHANGE HUB OPERATION

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ABSTRACT

A model of a transport interchange hub, made in simulation environment AnyLogi, is shown in the article. Its main functional blocks, the scope and features of its application are described. Means of optimizing design solutions, analysis and justification of directions, intensity and speed of passenger flows are estimated in a multi-tiered and multi-type urban transport environment.

ENGLISH SUMMARY

Background. *Transport interchange hub (hereinafter – TIH) is a set of individual passenger systems, within which the correspondence of passenger flows is conducted. Quality of TIH operation thus largely depends on the efficiency of the organization of interaction processes of its individual elements [1]. To ensure a required organizational level is a complex problem involving modeling.*

Objective. *The objective of the author is to investigate functioning of TIH, using special simulation package.*

Methods. *For computer implementation of TIH functioning model the author selected a domestic professional simulation package AnyLogic 7 University (Education version). For its construction the author also applied a pedestrian library AnyLogic, in which passengers are moving in a continuous space, responding to various kinds of obstacles in the form of walls and other passengers. [2] The logic of TIH simulation model is shown in Pic. 1.*

Results. *The author describes the objects of this developed model.*

PedGround – object sets the two-dimensional space in a simulated environment, which is the 2nd floor of TIH, that is the area, where passengers and visitors of the hub will move (here the highest percentage of technological areas is accumulated). The floor is limited with closed broken lines simulating walls – passenger flows cannot cross them.

PedSourse – passengers› generator, used as a starting point of a process diagram. People come in TIH with a given intensity established by the results of a survey of passenger flows during morning rush hours. During the experiment, the intensity of movements can vary within the expected range. Passengers, going to the interchange, get on the 2nd floor from passenger commuter platforms, monorail transport, intercept parking and the 1st floor of TIH. Commuter trains and monorail train arrive at TIH in accordance with the schedule that is set by a special module Shedule.

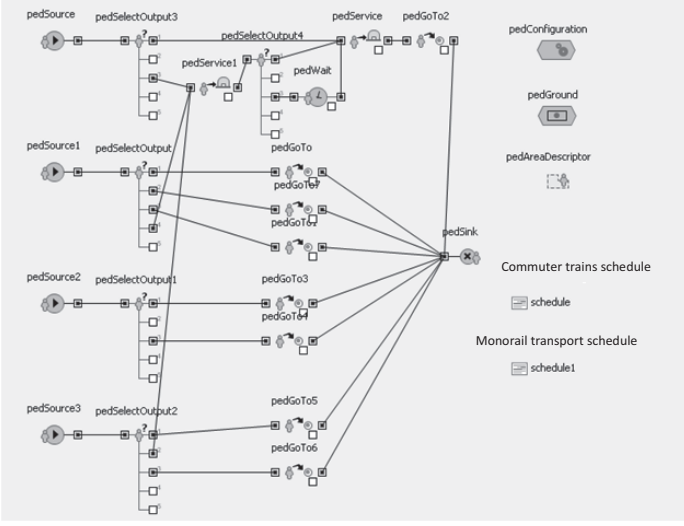
PedGoTo – object simulates the movement of passengers in the space of the 2nd floor of TIH, indicating them their route.

PedSink – object removes passengers, entered in it, of the simulated environment and is used as an end point of the process diagram.

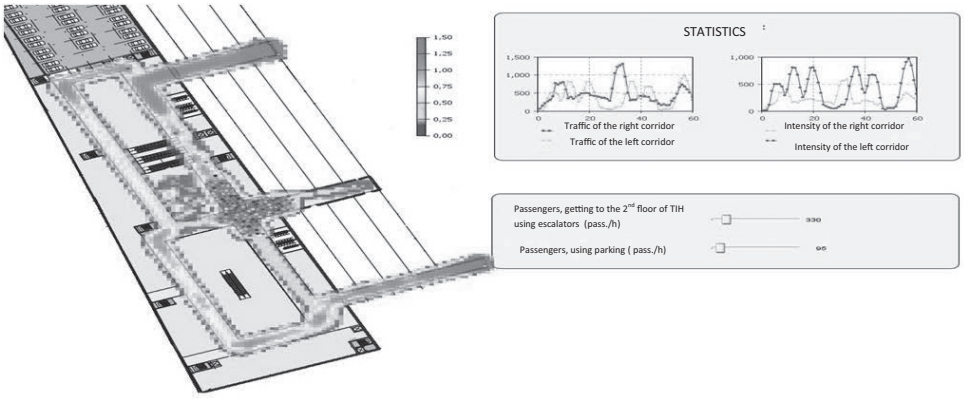
PedConfiguration – object allows changing the general settings of the process diagram of passenger movement, affecting performance of the model.

PedService – an object that is added to the process diagram for modeling the passenger service in a given service (ticket offices, turnstiles, ticket kiosks, etc.). With its help, queues and services are simulated in any combination and rules for the selection of services are established. The time of passengers stay in front of turnstiles is distributed in a uniform law with a minimum value of 2 seconds, maximum – 3 seconds. When simulating queues in the model it is possible to select the passenger queues on the following criteria: the shortest, the nearest, other (specific).

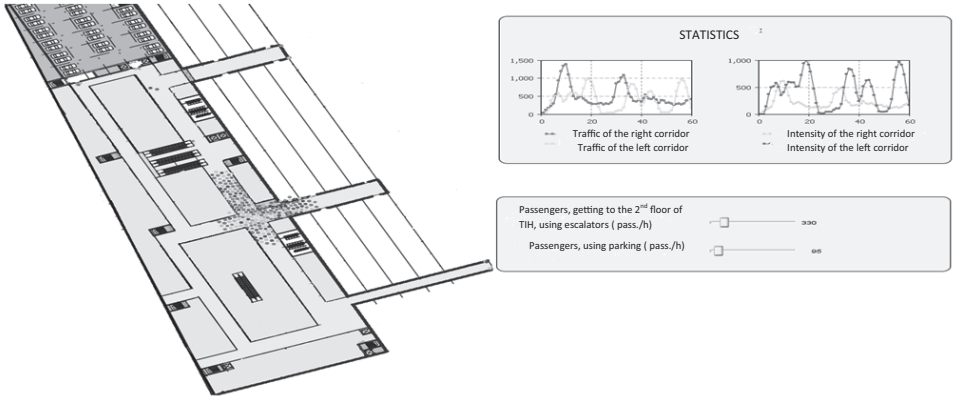
PedSelectOutput – unit of decisions. A passenger who entered this unit, will be forwarded to one of five output ports depending on the preference coefficients, set for them. Object PedSelectOutput is designed to redirect passengers without tickets to ticket offices, and passengers with tickets – to turnstiles.



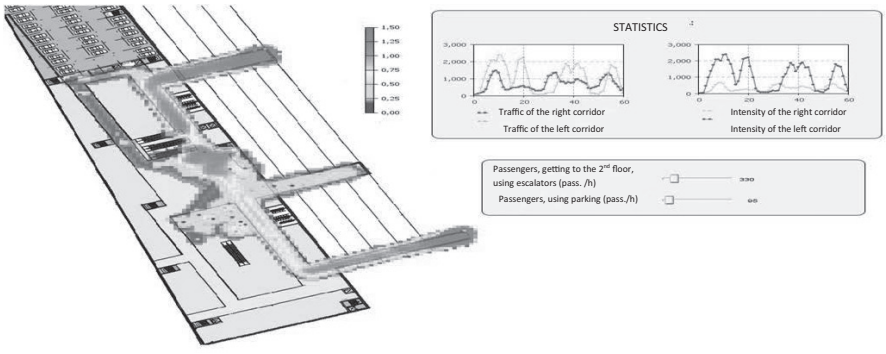
Pic. 1. The logic of TIH simulation model functioning.



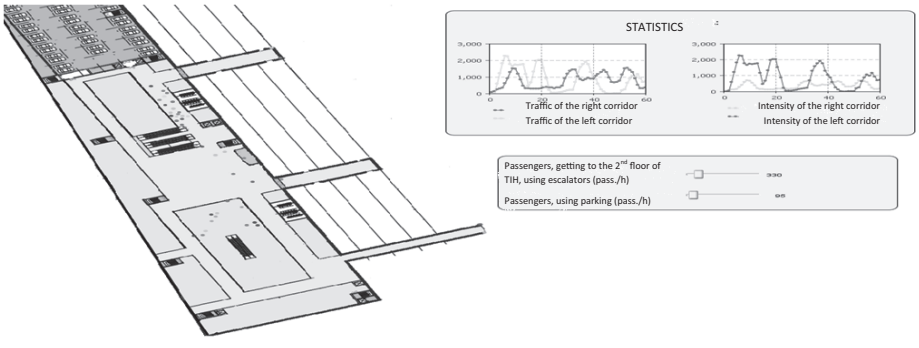
Pic. 2 The density of passenger flows in the simulated space of TIH.



Pic. 3. Formation of «bottleneck» in the central part of the 2nd floor of TIH.



Pic. 4. The density of passenger flows in an optimized space of TIH.



Pic. 5. The simulation results of the optimized design solution of TIH.

PedAreaDescriptor – simulates waiting areas for passengers of commuter traffic. Location of these areas and their space are determined on the basis of pre-design study for TIH.

PedWait – object that forces passengers to go to the waiting area and stay there for some time. To clarify the period of stay in the waiting area of commuter trains questionnaire survey was conducted. It showed that the required period fits in the interval of 5–10 minutes.

When constructing a model a particular focus was put on the distribution of passenger flows on the routes within TIH. Every passenger is associated with the purpose of TIH visit, presence of a travel document for the appropriate mode of transport, departure time of this mode of transport, to which a potential user is going to make his interchange, etc. Accordingly, the passenger chooses a route in the simulated space. It is possible to take into account in this model any kinds of behavior / reaction to the situation, there is also a possibility to change the speed of the passengers (it is different for various population groups, – people with disabilities, passengers with children, luggage, etc.) and their overall characteristics (children, adults, and so on).

Model takes into account the statistics of the intensity of passenger flows passing in interchange space through a given line (cross-section), and the traffic – the total number of passengers crossing the same line in a given direction (or both) during the last hour. Intensity is in fact a value of traffic divided by the length of the line (in meters), and is measured in passenger / (h • m). Traffic is measured in passengers / h.

Density map of passenger flows enables to display the dynamics of the simulated process of TIH operation and to find areas of the simulated space where the density of passenger flows becomes critical (1,5 passengers per m^2). The results of the simulation process are shown in Pic. 2 and 3.

As it can be seen from the results demonstrated, the proposed design solution of TIH does not ensure compliance with the conditions of fast and comfortable interchanges of passengers – at certain point of model's run «bottleneck» was formed. It occurred due to ineffectual location of ticket offices: people, standing in queues to them meet with passengers lining up to the turnstiles. The highest density of passenger flows is achieved in the left and right corridors in front of escalators working on the descent and ascent from the 2^{nd} floor. Taking this into account, redevelopment of the 2^{nd} floor of TIH was made: location of ticket offices was changed, zone of waiting areas was relocated. The resulting optimized version of TIH operation is shown in Pic. 4 and 5.

Time schedules of simulation statistics collection (intensity and traffic) demonstrate that, in the optimized version as compared to the original for the same model time (1 hour) 50% more passengers passed. Experimental runs did not reveal any cases of «bottleneck» formation.

The developed model allows changing:

– Intensity of passengers' arrival at TIH;

– Schedules of commuter trains and monorail transport;

– TIH design solution;

– The number of ticket offices, turnstiles;

– Speed of passenger flows in TIH and their sizes;

– Stay period of passengers in the waiting areas of commuter traffic, etc.

Conducted simulation revealed features of the proposed design solution of TIH and at the stage of pre-project studies led to the conclusion of feasibility, effectiveness and objectivity of the experiment based on the model as it helps to predict how TIH will work on ongoing version of the design solution.

The entire process of passenger flows simulation in TIH involves several steps:

– The collection of baseline data for the simulation (design solutions of the hub, the structure and size of passenger flows, their distribution by mode of transport, interacting in TIH, the number of ticket offices, turnstile lines, etc.);

– Construction of a simulation model for a single version of TIH design solution and given sizes of passenger flows;

– Carrying out a set number of tests on a simulation model to ensure the highest possible accuracy of the results;

– Determination of the optimal characteristics of passenger flows services;

– Optimization of TIH design solutions.

In view of these stages not only the fullness of solutions of initially assigned tasks is achieved (effective interaction of all elements of TIH), but also a view of the resource base of the project, the multidimensionality and variability of processes, combined by the planner, are formed.

Conclusion. *The developed model of the transport interchange hub operation makes it possible to demonstrate the modeled processes with help of animation and to track density of passengers in the different zones of the simulated space to make a well-founded conclusion on the system's ability to cope with existing and potential passenger flows, to identify potential problems of considered design solution, to determine the optimal characteristics of TIH objects.*

Keywords: urban transport, electric train, monorail, transport interchange hubs, passenger transportation, passenger flows, simulation, optimization of planning decisions.

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