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Simulation Modeling of Train Movement at Railway Stations Using Anylogic

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Abstract: This article discusses the issue of simulation modeling of train movement through railway stations in order to create a testing environment and create conditions for analyzing capacity and other indicators of the railway site.

Keywords: simulation modeling, Anylogic , railway, station, train.

Introduction

Anylogic railway library allows you to effectively model and visualize the functioning of railway junctions and railway transport systems of any level of complexity and scale. Marshalling yards, loading/unloading tracks for large enterprises, railway stations and train stations, subway stations, airport shuttles, tracks at container terminals, tram traffic and even rail transportation in coal mines - all of these tasks can be easily and accurately simulated using the Railway Library.

The Railway Library is integrated with other AnyLogic libraries - the Process Modeling Library and the Pedestrian Library, which allows you to connect railway models with models that consider in more detail the movement of trucks, cranes, ships, models of passenger flows, production and business processes, etc.

The railway library supports detailed, high-fidelity simulations (custom car sizes, precise track and switch topologies, train acceleration and deceleration), but these simulations are highly dynamic in execution, which can be important when optimizing in search of the best strategy.

The two main inputs to a railway model are the railway network topology and the railway junction operational logic.

The topology of a railway junction (this could be a marshalling yard, loading/unloading tracks, etc.) consists of special space marking elements designed for railway models: tracks, switches and elements that specify an offset on the track (railroad track point) . You can either draw these shapes manually in a graphics editor, or create them programmatically, for example, by reading data from a database.

The railway library supports a very simple high-level interface for specifying railway node operations. Library contains seven objects :

TrainSource

TrainDispose

TrainMoveTo

TrainCouple

TrainDecouple

TrainEnter

TrainExit

Using these objects, you can perform any operations with trains and cars without having to write program code. Moreover, railway node process diagrams can include Process Modeling Library objects such as Delay, SelectOutput, Hold, Seize, Release, Queue, etc. This means that the operational logic of railway nodes can now be completely defined graphically by simply dragging and dropping objects (drag-and-drop style).

Method

Trains are created by the TrainSource object, which allows you to set any parameters of the created train and its cars. The TrainMoveTo object controls the movement of trains. This object supports automatic calculation of routes and changes in switch states as the train passes along the route. You can also set the train to accelerate to cruising speed and decelerate before arriving at its destination, which provides more accurate simulation results and makes the process more realistic. Coupling and decoupling, performed by the TrainCouple and TrainDecouple objects, respectively, is also very simple and at the same time flexible. Finally, the TrainDispose object can not only remove trains that have left a junction on an open track, but it can also "dispose" trains that are still on the tracks of the junction - a functionality that has been requested many times by simulation modelers.

The logic for sharing railway node resources, such as tracks and switches, can now be specified using resources and corresponding resource objects in the Process Modeling Library. For example, if part of a node (say a track) needs to be blocked to allow a train to pass, then you can associate a resource with that part of the node. Then the train that appears will have to seize this resource for its use, and the remaining trains will wait in the queue for the Seize object. For the same purposes, you can use a Hold object and a pair of RestrictedAreaStart/RestrictedAreaEnd objects.

The SelectOutput object can be used in railroad process diagrams to select between different process branches, and the Delay object can naturally model stop durations or operation durations such as coupling/uncoupling or loading/unloading.

Animations of tracks, switches, and cars are automatically created by the library. The railway library also supports the creation of 3D animations. Tracks and cars can now be part of the model's 3D scene. The palette of standard 3D images 3D Objects contains ready-to-use 3D objects of a locomotive, a passenger car, and various types of freight cars. Because both the Process Modeling Library and the Pedestrian Library also support the creation of 3D animations, you can now easily create fully dynamic 3D models of train and subway stations, airport shuttles, and other systems where rail transportation is present as well as passenger traffic.

For modeling, 3 stations were selected through which the prefabricated train will pass. The train will stop at an intermediate station to uncouple the cars. At the final station, the process of disbanding the train with settling will be carried out.

The model consists of the stations Toshkent Tovarny, Salar, Chukursoy. Let's start with modeling the Toshkent Tovarny station. We find a shape file for the railways of Uzbekistan from the OpenStreetMap library. Let's integrate this file into our project. We trim the station park that we will need and save it.

The next thing we will do is build the logic of the system. Trains will be formed sequentially and will be located along the tracks. After all tracks are filled, trains will begin to depart, while maintaining safe movement along the switches (Fig. 1).

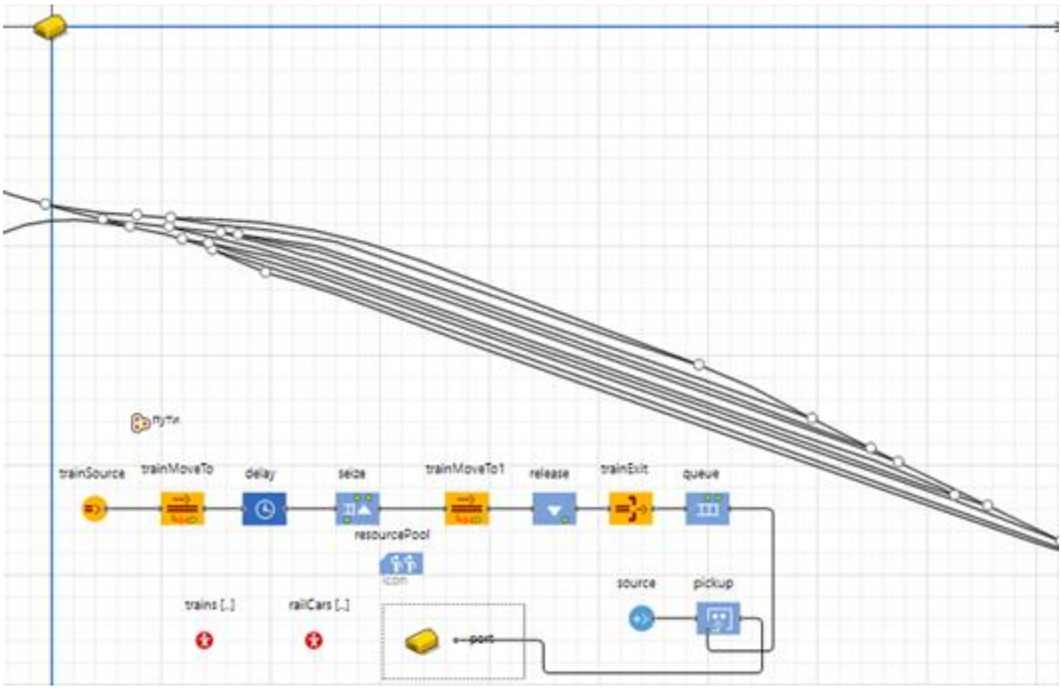

Figure 1. Model of the Toshkent Tovarny station

At the Salar intermediate station, the train is accepted onto the receiving and departure track. Then the shunting locomotive will uncouple a certain number of cars from the tail. The train departs to Chukursoy station after completion of work on the train (Fig. 2).

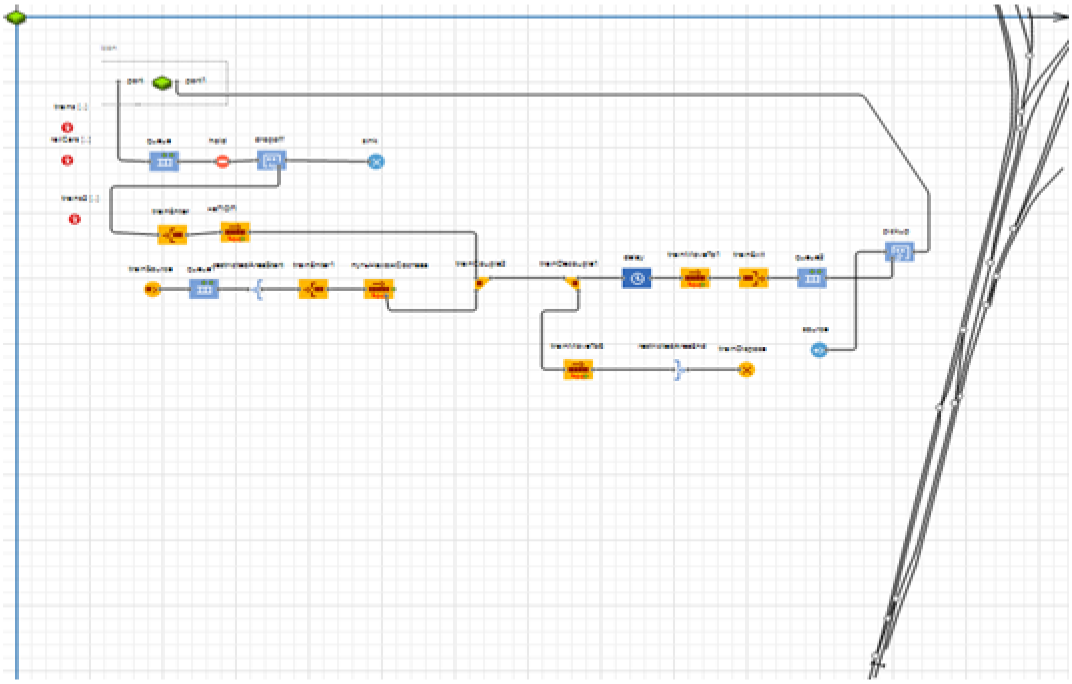

Figure 2. Salar station model

At Chukursay station a park is selected for disbandment. It is set in the disbandment path settings and the cars will be randomly distributed along these paths. A certain number of cars will gradually be collected on the accumulation tracks; a separate shunting locomotive, after more than 10 cars have accumulated on one track, removes these cars from this track.

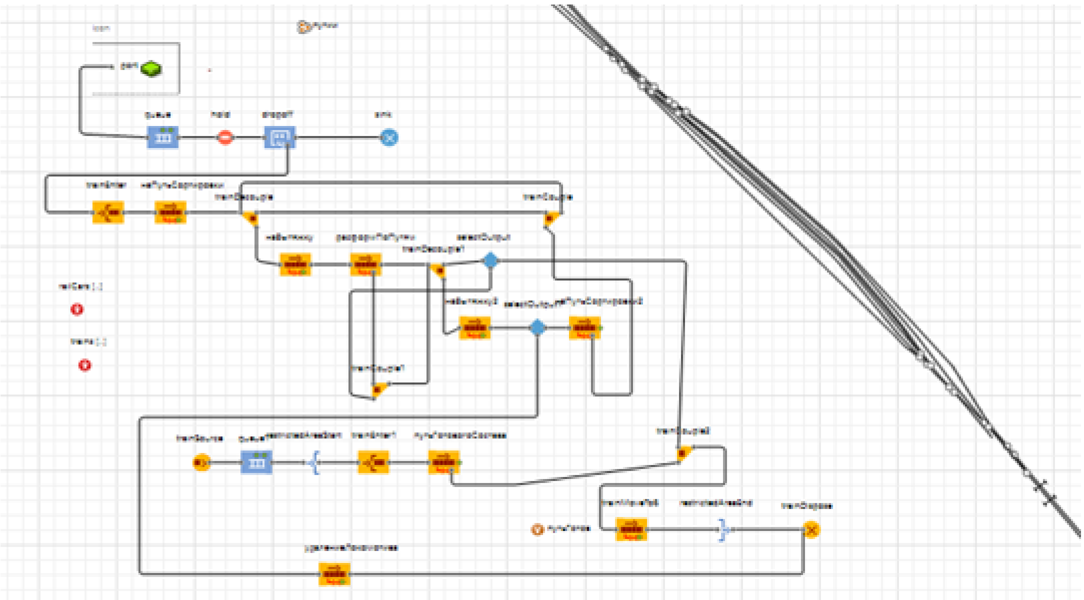

Figure 3. Chukursoy station model

Train movements along sections can be tracked using a GIS map. Trains will pass along the railway tracks at a given speed. To do this, it will be necessary to install additional train movement logic (Fig. 4).

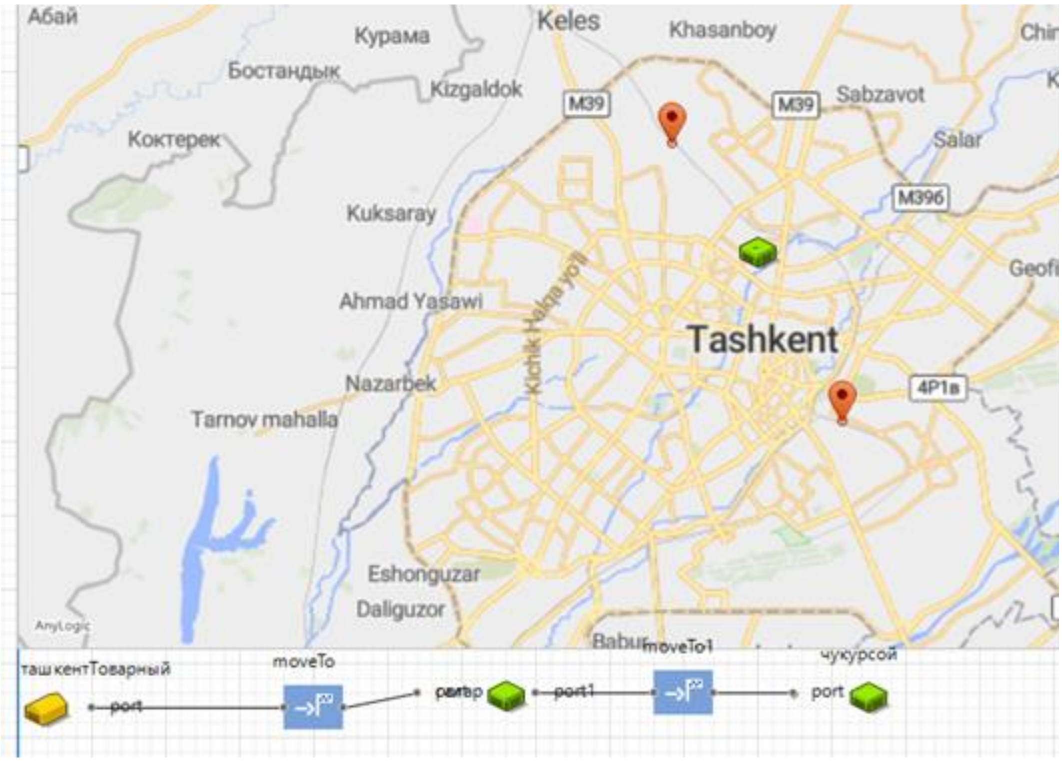

Figure 4. Model of a railway station station

Results

We launch the simulation model and check the operation of the installed logic.

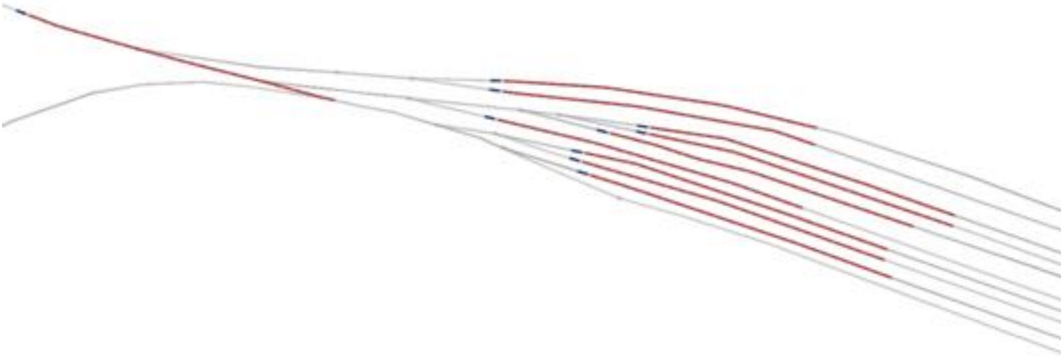

Figure 5. Train movement at Toshkent Tovarny station

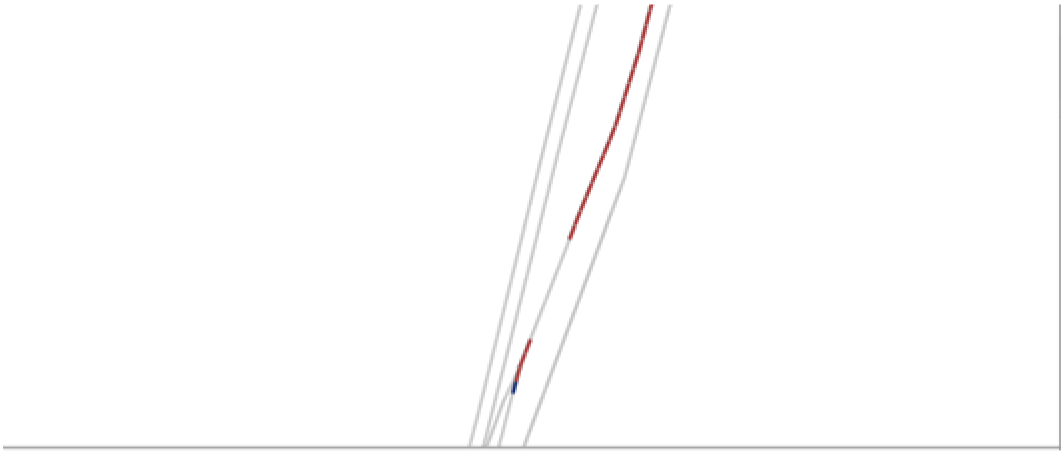

Figure 6. Uncoupling of cars at Salar station

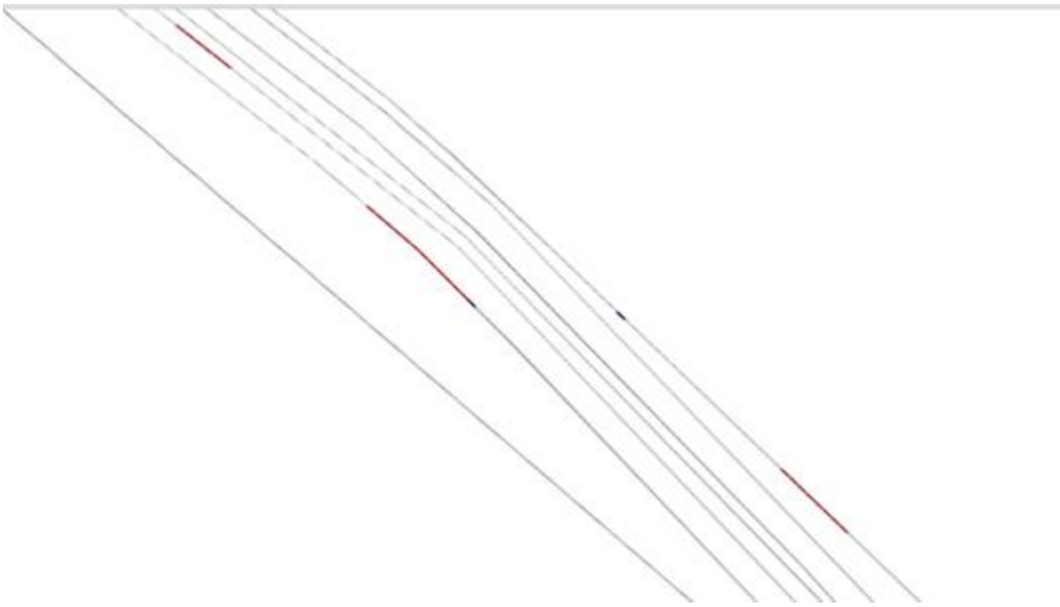

Figure 7. Disbandment of cars at Chukursoy station

Figure 8. Train movement according to GIS map

Discussion and conclusion

Simulating the movement of trains along a railway section using AnyLogic can provide a range of benefits and information. Here are some of them:

1. Performance Assessment: Simulation allows you to evaluate system performance and identify bottlenecks in the infrastructure. This can help optimize train schedules, improve turnaround times and increase capacity.
2. Delay and Downtime Analysis: Modeling can help identify the causes of delays and downtime in train operations, which in turn can lead to improved management and prevention of potential problems.
3. Infrastructure Optimization: Simulation results can help optimize infrastructure configuration and parameters such as path lengths, signaling distribution, etc.
4. Scenario Analysis: Simulation enables scenario analysis to evaluate the impact of changes in infrastructure, traffic patterns, or other parameters on system performance.
5. Risk Management: Modeling can help anticipate potential risks and problems, allowing you to develop strategies and measures to mitigate them.
6. Training and Testing: Simulation can serve to train personnel and test new strategies and technologies without real risks or costs.
7. Evaluating Investment Efficiency: By introducing changes to the model, the effectiveness of investments in infrastructure and technology can be assessed.
8. Improved Safety: Simulation can be used to assess the impact of various factors on train safety and to develop measures to improve it.

AnyLogic provides flexibility in creating such simulation models, making it a useful tool for analyzing and optimizing rail transport systems.

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