RBSIM- simulation model of marshalling yard operation
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Abstract

This paper deals with a simulation model of technological procedures in a marshalling yard. The structure of the model and its properties are described from the point of view of a user. Attention is paid namely to its flexibility and built in capacities of cooperative solution of problems during the simulation run.

1 Introduction

Marshalling yards are such nodes of a railway network, which are equipped with costly technology and in which technological procedures of high complexity are performed, demanding a high degree of coordination and control skills. It is only natural that a great effort is exerted to find an optimal configuration of infrastructure, to exploit to maximum technical and human resources and to organize effectively the technological procedures. Because of the complexity of the system, the only tool suitable for its investigation in realistic conditions seems to be a simulation model.

Authors of the paper are members of research group developing such a tool, named RBSIM, which is now in rather advanced stage of development.

In the next, we shall try to explain the most important properties and possibilities offered by the model from the point of view of its potential user.

2 Required properties of the model

Properties of the model are derived from the needs, which are supposed to be satisfied by its use. The model should serve for investigation of variants in the infrastructure configuration, service resources, technological procedures,
decision making and even of variants of control strategies. It should permit to evaluate the changes in the environment of marshalling yard (seasonal influence, exceptional situations due to e.g. strikes or weather, cancelling or change of capacity of another marshalling yards, etc.).

The model should be capable to serve for investigation of any marshalling yard. A high degree of flexibility is required to supply the user with the possibility of modelling a broad scope of situations without the need of incursions into the computer programme. It should permit the investigation of the system on different levels of detail, even the lowest ones.

It should enable a close cooperation between the model and the user - experimenter, mainly in the decision making. It should support the graphical environment with the possibility of animation. It should supply the user with the information on the state of the system and its statistical development during the simulation run. Also a broad post-simulation palette of statistical and other information on the system should be given, with the possibility of adding new items to the palette.

3 Simulation model structure

Elements of the system, marshalling yard, can be divided, according to their role in the system, into the following subsystems (fig. 1):

- stable subsystem
- mobile subsystem
- control subsystem

Stable (fixed) subsystem contains all elements which do not change their location in the process. This subsystem is also called infrastructure. Modelling infrastructure, we distinguish the following parts:

- set of tracks
- signalling system
- block system

Set of tracks consists of track sections of different lengths (tracks and switches). We can further distinguish the tracks destined for the attendance of trains (service tracks, fixed servers) and exchange tracks, which serve for connecting the service tracks (e.g. switches).

Signalling and block systems are modelled accurately, having the same function in the model as in the real marshalling yard.

The model of stable subsystem is created by a user in the frame of Autocad editor. Space arrangement of tracks and locations of individual items of signalling and block systems are defined. This information on the infrastructure presents one of the basic pieces of input data for the simulation programme.
Mobile subsystem of a marshalling yard contains such elements (mobile elements), which may change their location in time. They form two groups:

- elements subject to service (attendance)
- servers (resources)

Elements (objects) to be served are represented in the model by trains or by parts of trains. The service they are subject to is for example technical inspection, shunting of a set of wagons, etc.

The arrival of trains into the marshalling yard is modelled by the input train generator. It can be tuned by parameters to correspond to the time schedule and to the train composition of a chosen yard to be simulated. The documents needed for acquisition of these data are timetable for goods trains and wagon lists of arriving trains. The data are statistically processed and probability distribution tables are created for each relevant train characteristic. Some of the most important characteristics are:
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- train number
- actual arriving time
- length and weight of train
- composition of train (information on every wagon and its destination)
- number, lengths and order of cuts in train

The probability distribution tables can be updated by adding and processing fresh data. The mobile elements are:

- shunting locomotives
- gangs

Shunting locomotives do the transfer of the sets of wagons. Gangs, specialized in different professions, attend standing trains (e.g. inspection in reception, brake inspection, commercial traffic inspection, etc.).

Integrated editor of mobile elements permits the user to choose number of shunting locomotives and number and composition of gangs, corresponding to the real marshalling yard configuration.

Finally, the control subsystem consists of elements modelling the following activities:

- decision making activities of dispatchers in the marshalling yard
- execution of obligatory technological procedures in the train attendance

Modelling the decision making activities of dispatchers is a very complicated problem, belonging to the field of artificial intelligence. The decision making algorithms should simulate the work of an intelligent dispatcher. Therefore, these algorithms were developed and programmed by software specialists and the user is only offered a choice from the palette of different modifications.

Those control activities, which can be expressed as a prescribed technological procedure, were described by network graphs. This form of description allows very aptly to present all conditions and time dependence in execution of individual technological steps. Graphic editor is very helpful to the user in constructing different variants of technological procedures, which are then interpreted by the simulation programme. There are two fundamental technological procedures:

- technological procedure for the train attendance in the train reception
- technological procedure for the train attendance before the train departure

4 Parameters used in the simulation modelling

Before the simulation run a user can edit and keep in a database any number of variants of the elements of the yard, defined in Section 3. It means that any number of variants of infrastructure, gangs, etc., can be kept in the database.
Individual variants differ from each other by the values of their parameters. However, parameters here are understood in a very broad sense (e.g. decision making procedure or the whole control strategy are considered as parameters).

Setting of these generalized parameters for a real marshalling yard is called setting scenario for a simulation run. A user can do it easily, choosing from the menu of elements of the yard one item of each kind. Scenario created such a way is given a name and can be stored in the database of scenarios. Each simulation run then follows a selected scenario.

Degree of freedom in scenario setting characterizes a degree of flexibility of the model. This is one of the most appreciated properties of the model and therefore a special attention has been paid to it.

First, user can select any variant of infrastructure as a basis for modelling of dynamic processes in the prepared simulation run. Similarly, a particular set of locomotives and gangs can be selected. Also a particular input flow situation is chosen, for example, we may set the statistical characteristics of arriving trains for any day in a week.

By selection of a technology procedure into the scenario, a user chooses the way of attendance of different types of trains. For example, one technology procedure attends the departing trains on the sorting tracks, another on the departure tracks.

Simulation programme contains tens of decision algorithms. Any one of them can be kept in the database in several variants. Any variant can be chosen by the user into the scenario. Decision algorithms are grouped with respect to the area they control (e.g. all algorithms for the control of operation of shunting locomotives belong to the same group). The group as a whole can be selected into the scenario. It means that a strategy of control in an area is chosen (e.g. strategy of shunting locomotives operation control).

Finally, the simulation model RBSIM supports the possibility of control modelling by operation plans (for gangs, locomotives, tracks humping plan, etc.). Any of existing plans can be selected by the user into the scenario. In this area we are facing serious problems. Situations occur, where plan cannot be followed because of the stochastic nature of processes involved. So far, this part of the model is not completed and problems connected with it are under investigation.

5 Simulation run control

Before triggering the simulation run, user has the possibility to plan some standard activities which are to be carried on during the simulation. These activities are: interruption, termination, making snapshots of the system state, etc.

The less standard property of the model is the capability to choose strategy of solving problems which occur during the model operation. We have mentioned tens of decision algorithms built in the model. But triggering a particular decision procedure supposes identification of a problem. The model is
capable identify several tens of problems and propose their solution. However, this automatic solution is only one of three possibilities. The next two possibilities are plan and user. For each problem, user can propose the mode of cooperation of these three agents in the problem solution.

Let's see first, who can identify a problem during the simulation. It is, of course, the simulation programme where this capacity is built in. Next, it is also the user - experimenter with the model, while following the development of the system on the screen. In both cases, the one who identified the problem, can interrupt the simulation run. In addition, experimenter can also plan an interruption beforehand whenever he feels a precarious situation may occur. The interruption permits to carry out the following activities:

- propose the problem solution, following the cooperation mode valid for this case
- set a new cooperation mode valid henceforward

Setting the cooperation mode is done in a dialog. The next examples illustrate some of the possibilities:

- solution is proposed automatically and is subject to confirmation by the user; if not confirmed, the user proposes another solution
- solution is reserved exclusively to the user
- solution is reserved exclusively to the programme, user is informed during the interruption but is not authorized to intervene
- solution is proposed by the plan, if it is unreal, a new solution is proposed by the user

These examples demonstrate why the simulation model RBSIM may be better characterized as cooperative than interactive.

6 Simulation output

During the simulation run we may follow the "live" development (change of values) of selected characteristics in graphic presentation (e.g. utilization rate of selected locomotive).

Another type of output information is the overall information retrievable after termination of the simulation run. To this purpose, a detailed protocol on simulation is generated during the simulation run. These protocols can be processed separately and a sought for information can be retrieved from them. Namely it is:

- statistics
- detailed time-dependent reports on utilization of servers (locomotives, reception tracks, hump, etc.).
Different statistics are obtainable from the palette of possibilities. The palette is open to adding new items according to the wish of the users. Reports on utilization of servers can be produced in graphic presentation either for individual servers or in an integrated form, e.g. by Honnemann or by Mueller schemes. On the other hand, the time-dependent report on the activities of an individual server (e.g. gang) in data presentation may be used in another simulation run as a plan of prescribed activities for this server. Naturally, stochastic nature may cause collisions in the execution of the plan, but it can be tuned to be sufficiently robust, i.e. feasible for rather a broad scope of system conditions. This possibility of interactive plan creation will be prospectively built into the model.

7 Conclusions

It is evident from the above description that development of a simulation model of marshalling yard satisfying desired conditions is a very complex and interdisciplinary task. In its solution the research team is confronted with problems from the following fields: mathematical theory of transport, queuing theory, graph theory, simulation modelling, railway technology, computer graphics, database systems, artificial intelligence and mathematical statistics.

In the design of the simulation model architecture, a new methodology of simulation models construction was developed [1] - [4] and also a new supporting software was created for its implementation. The simulation programme runs on computers PC compatible.

The simulation model architecture of marshalling yard is open to the possibility of its incorporation into the network of marshalling yards with the outlook of creating simulation model of the network.

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References


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