

SIMULATION MODEL OF PASSENGER RAILWAY STATION OPERATION

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Článok sa zaoberá vývojom simulačného modelu prevádzky osobnej železničnej stanice. Autori sa snažia definovať a odôvodniť ciele, ktoré sú sledované pri uplatnení modelu v praxi. V ďalšej časti sú opísané rôzne druhy údajov, ktoré sú potrebné pre zostavenie takého simulačného modelu v simulačnom nástroji VirtuOS[®]. Ako testovací príklad, na ktorom sa simulácia prevádzky osobnej stanice v spomínanom simulačnom nástroji vyvíja, bola použitá Žilina, hlavná stanica.

1.Introduction

Simulation model of marshalling yard has been developed at University of Žilina already. Its successful practical application confirmed that the computer simulation can be useful when testing the operation of either existing or designed marshalling yard. Here, a question appeared: Can be the computer simulation useful also for the operation of passenger railway station? That led us to an attempt to identify possible goals and problems which could be addressed by a simulation model of passenger railway station operation and to construct the model using all the experience gained. We will try to present the result of our effort until now in this article.

2.Goals of the simulation model

We have tried to classify the goals into these four groups:

- To get working plans of the current or proposed station operation.
- To see the influence of planned modifications on the station operation.
- To get an idea how to handle exceptional situations - crisis management.
- To have a mean for training of station managers.

The first and the fourth points are very similar to the goals pursued in the simulation of marshalling yard operation. The second point is very similar also, but it may include different types of modifications in the passenger station operation. The third goal needs not to be specific for the passenger station operation, because the exceptional situations can occur also in the marshalling yard. However they have much larger influence on the passenger railway station operation.

2.1. Working plans of the station operation

What a simulation model has generally to offer is

- the graphical view of the station operation in very short time of simulation run,
- the text view of the operation - simulation protocol and the statistical evaluation.

The graphical view of the station operation is very useful. What takes hours in reality, is simulated just in few minutes in the model. It is possible either to see the station as a whole or to concentrate on some parts of the station. The same simulation run can be processed with the same parameters more times, thus allowing us to re-run what we have seen already in order to analyse the problem closer if we need so.

The simulation protocol reflects the simulation run that has been accomplished. It shows how the resources, that are tracks, locomotives and personnel, were utilized during the period of simulation, at which periods the capacity was not fully used, at which periods the resources were overloaded, where the technologies have critical parts, etc. The statistical evaluation gives us total results of resources' utilization, thus saving us time for manual calculation of these results.

Both features have another advantage. They both give to the user a different view angle for looking at the station operation. They may make easier to understand the dependencies among elements and to find possible problems.

The features are much more helpful when the model represents a not yet existing, but planned station operation. The simulation gives more precise view and statistical evaluation of something what is only on the paper, what cannot be seen in reality and thus can be only estimated. The same applies, if the model represents an existing station operation with some modifications. This topic is discussed in the next section.

2.2. Influence of modifications

What do we mean by modification here? It is a derogation from regular operation, deflection from timetable which is anticipated or planned for some period of time, either hours or days or weeks, depending on the situation. For instance, what happens, if

- we need to cut off one platform because of refurbishing?
- we need to close, due to reconstruction work, an important transiting track between the platforms and the exit of the station?
- we need to service more trains from a certain direction?
- we reorganize the system of reserving tracks for trains of certain direction?

These questions and many others that may occur in each passenger railway station from time to time, could be answered with help of the simulation model. We just need to change parameters of the model and can run another simulation run.

Furthermore, the model provides us easily and immediately with the look of the station operation in the new conditions and gives us an idea, whether the modification was acceptable or not and what could be further improved. Certain experiments may not be easy to realize in reality, because people usually have natural resistance against changes and it takes time to become accustomed to the new situation and procedures. The model can show it immediately and almost exactly.

2.3. Crisis management

Crisis management is applied when an exceptional situation occurs. It may have similar

effects as described in the previous section, for instance closing a track or overloading with coming trains, but here, it is an unexpected, unforeseen situation, which sometimes happens suddenly. It is caused by events in external environment, for instance floods, war, but mostly train delays. You agree probably that if a train is delayed, it makes some sort of exceptional situation in the station. Departures of some trains may be related to arrivals of other trains. Thus, if a train is delayed, another train may wait for it and become delayed also. Schedule of track utilizing is then broken and the situation must be solved by the station inspector.

The situation gets even more complicated, if the tracks at the station are not assigned to individual directions, but they are used variously. The station inspector must then consider not only time conditions, but also spatial conditions (occupation of tracks). If the track of the delayed train in the time of its coming is occupied, another free and acceptable track must be chosen. Furthermore, the station inspector many times should not consider only the current situation in the station, but also what trains are coming and how can their handling in the station be influenced by his current decision.

Giving the best solution to the station inspector is not a goal of the simulation model. However, the model should be able to show at least what happens, if the station inspector chooses each of available alternatives. In better case, it should be able to give him some hints, which track or tracks to choose to get relatively good solution.

The time connections may be easily entered in the model, also some hints on which solution to offer in some specific situation. However, since the exceptional situations are unique, it is very difficult (if possible at all) to find hints for all the possible exceptional situations.

This is the goal, which differs from goals defined for marshalling yard operation models the most. Although exceptional situations caused by delayed trains occur also there, they usually do not have such critical impact on the station operation. They are expected there and the station operation is prepared to handle them to a certain extent, without big impact on the whole station operation. In the passenger railway station, this is usually not so easy. Thus this point is the main goal to be pursued in the current development of simulation of passenger railway station.

2.4. Training tool

As it was discussed above, the model shows the operation in the whole station at once in shorter time than in reality. It has the specific properties and rules of the station operation included in it. Thus, it may become a useful support tool for instructing of new managers of the specific station, for instance station inspectors, dispatchers, signal operators, etc. They may see the operation in the whole station as well as in its different parts. It can help them to gain the first insight on the operation before attending any practical exercises at the station.

3. Simulation tool

As simulation tool, we are using our own software called VirtuOS[®]. It has been originally developed for the simulation of marshalling yard operation. Now, it is getting features for simulating of passenger railway station operation also.

In this section, we will try to describe roughly all the data types required for a simulation model of passenger railway station operation. They are required for the current level of simulation tool, but it may change with further development of the tool.

Further, we will describe the station serving as the first model of passenger railway station.

3.1.Data for the simulation model

We may divide the data types into these groups:

- infrastructure (physical, logical),
- work resources and their attributes,
- technologies,
- trains and timetable.

3.1.1.Infrastructure

VirtuOS[®] does distinguish two categories of infrastructure.

Physical infrastructure comprises tracks, switches (both with their numbers), track end points, signals and buildings. It is obtained from the station layout by scanning and further processing, when the individual elements are retrieved from the image with help of special software tools. All except buildings are necessary for the simulation. Buildings are useful for user's orientation in the station layout displayed on the screen, otherwise have no function.

Logical infrastructure defines professions of the tracks, which are then assigned to tracks. This is necessary when even differences in using individual tracks occur.

3.1.2.Work resources and their attributes

Work resources comprise, apart from tracks discussed above, locomotives and personnel. All of them have their own set of attributes necessary for the simulation.

Locomotives need to have defined besides basic parameters like type, weight, length and service time, also their depot and other service tracks, movement speeds and behaviour generally and in certain situations. The simulation tool allows to recognize 2 basic types, train and shunting, and each of the types can have as many different types as necessary.

Personnel include all people who take part in the defined technologies. Every person is given profession and working schedule among other attributes.

3.1.3.Technologies

The definition of technologies is based on network graphs, where each edge represents one activity in technology and each node ensures dependency between activities.

Technologies are one of the most crucial parameters of the model. Their definition influences the accuracy of the model. Other parameters, derived from the work resources also, are depend on the technologies. This is the domain, where the development goes on by trying to reflect the reality closer and closer.

3.1.4.Trains and timetable

As for information about trains, it includes the chosen locomotive type from the list defined in the work resources section and train set. The train may have different sets for every day, if necessary. The set may have a fixed or variable composition of cars from catalogue. The train car catalogue keeps car attributes like type, length, number of axles, weight, capacity, etc.

Timetable or timetable-like data type does not contain only information about train arrivals and departures, but also reserved station tracks, set modifications made at the station, if there

are any, and connections to other trains.

3.2. Žilina Central station - test example

The central railway station in Žilina has been taken as the test example - the first station, on which the simulation model of passenger railway station has been developed and tested.

The railway node in Žilina is quite complex. Three main 2-track electrified lines and one local 1-track non-electrified line meet in it. The main lines come from:

- the south-west, from Bratislava, capital and the biggest city in Slovakia,
- the north, from Čadca and Czech Republic,
- the east, from Košice, the second biggest city in Slovakia.

The local line is from south, from Rajec.

The three main lines make a triangle in the middle, which has two larger stations situated on its two ends. On the south-western end, there is Žilina Marshalling Yard; on the eastern end, there is the Central station of Žilina. Both stations are electrified, the latter having, apart from other, passenger, freight and stock parts. Although its operation includes more operation types, the passenger type is nowadays dominant and relatively independent from the others. That is why our simulation model concentrates almost exclusively on the passenger part of the Central station without taking the other types into account.

The passenger part of the station consists of two sidings. The main siding has seven transiting tracks. Five of them are situated by three platforms (two of them accessible via foot tunnel) and the other two have limited access from the first platform. The second siding has four cut tracks with small platforms used for starting or ending trains on the western end.

The passenger trains come from all 4 directions as it was mentioned above. About 180 trains per day are roughly divided into thirds: about 60 trains are fast transiting trains on the main lines, 60 trains starting and 60 trains finishing their journey in Žilina from all lines. Apart from some trains, the train intervals are not regular. The capacity of the passenger part of the station is almost fully utilized at peak times. In the other periods, it could hold more trains.

As for freight trains, there are some of them, which are processed in the marshalling yard of the Central station. This is almost independent from the passenger part operation at the station. There are also transiting freight trains, mostly coming from or going to the Žilina Marshalling Yard and using one of the transiting tracks as described above. These trains have an influence on the watched passenger operation, however it is not serious, since their movements are usually in the off-peak periods in the passenger train timetable.

As for types of technologies accomplished on passenger trains, we can outline these:

- the train sets staying in the station are cleaned internally as well as externally in a cleaning station situated just outside the Central station on the western end,
- some of the sets need to be repositioned between the platform track and stock siding,
- some of the fast trains exchange direct cars, that means one or few cars are disconnected from the original train and connected to another train on the same or another track, being or not placed on a temporary track in the meanwhile.

As you can see, the technology samples comprise most of the movements in the passenger railway station. However, there are not technologies existing in other stations like splitting a train set of incoming train into two outgoing trains or vice versa. We are trying to accommodate the model for these also.

4. Conclusion

The attempt to build the first simulation model of the passenger railway station operation has begun successfully. The simulation tool VirtuOS[®] is being accommodated to handle the passenger train operation also. We hope it may become useful in solving the problems, outlined or others too.

All this is possible only thanks to the cooperation with the people from the Žilina Central station. We would like to thank them in this way.

5. References

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