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MODELLING THE TRAFFIC SYSTEM

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Abstract

The paper presents the simulation study results of the traffic system in the city of Hlohovec. The authors describe the process of building the model in Witness 2013c simulator. The individual entities of simulation model are explained in details, as the Witness simulator is primarily suitable for manufacture or service simulation and not for traffic system simulation. The goal of this paper is to analyse the traffic system and to suggest the changes for improving the traffic in the city of Hlohovec. All proposed measures will bring about 20% improvement of traffic when compared to the current state.

Key words

traffic system, simulation, model

Introduction

The traffic system of Hlohovec is quite simple; nevertheless, the traffic is very intense at the time of rush hours. The paper aim is to analyse the traffic system in Hlohovec and identify its critical problems. The researched area of the traffic system in Hlohovec (Fig. 1) represents a section lying on the II class roads No. 507 and No. 513. The traffic section about 700 meters long (1).

***Fig. 1** Research area of the traffic (Google, 2014)(2)*

This system consists of one roundabout, three T-junctions and two 4-way crossroads, a car park and seventeen zebra crossings (one of them being a pelican crossing). The Witness simulator was used for designing the model.

Witness simulation model

Witness is primarily intended for designing the models of manufacturing and service systems, not for traffic systems. In spite of this fact, it enabled designing the simulation model of traffic system for the city of Hlohovec. The simulation model of given traffic is shown in Fig. 2.

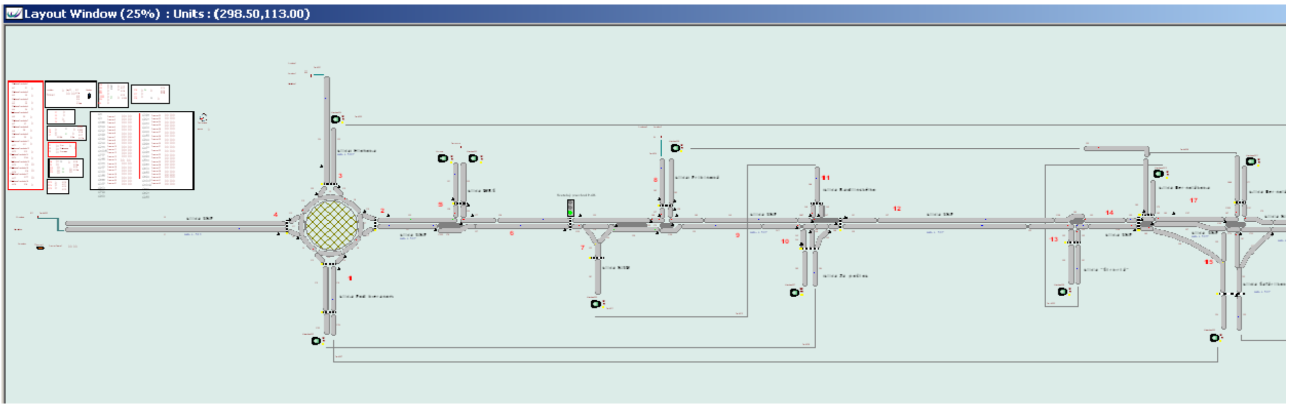


***Fig. 2** Witness simulation model*

Entities of model

Roads

A continuous queuing conveyor was used for modelling the partial sections of roads. This entity is the best way for appropriate modelling the attributes of the road, i.e. length, maximum number of vehicles apt to the road section, speed of the vehicles, distance between vehicles, etc. Path entity was used for some of the road sections, without the need of being modelled in details.

Vehicles (cars)
The moving vehicles represent the basic elements of the traffic through the system. In the system, there are three types of vehicles - a personal car, a bus and a truck. Each type has its defined attribute – length. These elements were represented by the entity Part. Vehicles enter the system from four different directions. All directions and types of vehicles have set their own 24-hour arrival profile divided into 30-minute time sections. The profile is read from MS Excel.

Zebra crossing
Zebra crossing is represented by a Single machine entity. Pedestrian is modelled as a passive Part entity. This part is called out of world by the element of zebra crossing according to the proposed algorithm. Time of crossing is set as a cycle time. At that moment, the relevant roads blocked and vehicles are stopped on this road.

Parking area
This element is modelled by Buffer with defined capacity.

Implementation of the model parts

Roundabout
This object is composed of Roads entities (modelled as elements of type continuous queuing conveyor) and Zebra crossing (representing the element of single machine type). Implementation of the roundabout is shown in the Fig.3.

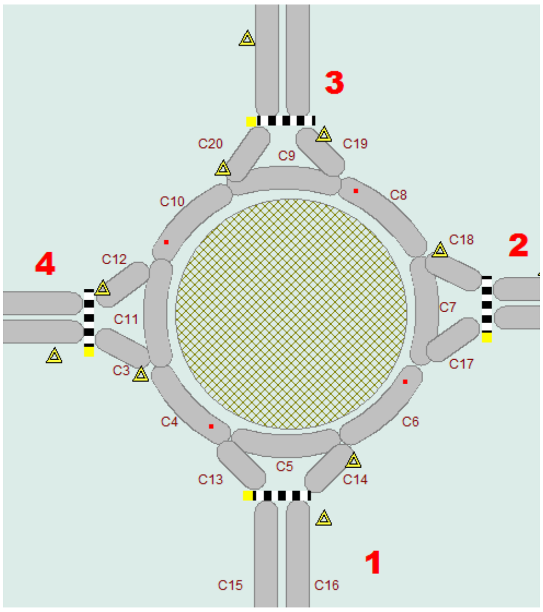


Fig. 3 *Object of traffic - Roundabout*

At every point of the traffic system, there is a sensor for direction evaluation with the possibility of the direction change. Each vehicle has a defined attribute - direction, generated whenever the vehicle can change the direction. Generating is implemented by the user-defined discrete integer distributions corresponding to the statistical distribution of the changes in the real driving direction system. Information about the driving change is identified in conveyor element by sensors. On the base of the value of the direction attribute, it is set to variable R.

According to this value, the output from conveyor element is carried out by the conditional statement.

The state of zebra crossing element is also sensed. The identification of a stopping car (in the case of a pedestrian passing through the zebra crossing) is implemented by the ISTATE function. If the state "Busy" is indicated, the vehicle is to wait until the pedestrian passes through. On the other hand, if state "Idle" is indicated, then the cars continue driving.

T-junctions
There are four T-junctions in the model. Let us explain the following example. The T-junction and adjacent car park are shown in Fig. 4.

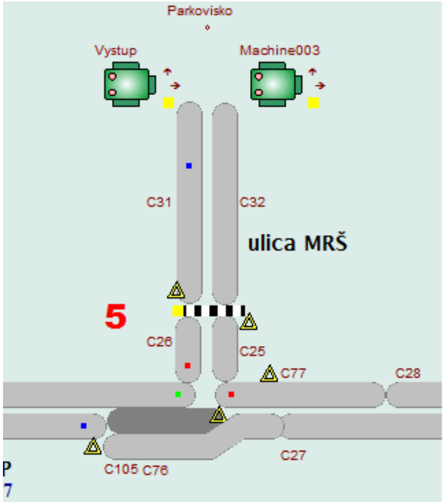


Fig. 4 *Object of traffic – T-junction MRŠ*

This object is also represented by Queuing Continuous Conveyor elements. The control method is the same as in the roundabout. The difference is in the control of the crossroad when a car changes the direction into the side road towards the car park. Here, it is necessary to determine the occupancy rate of the side road. This is determined by the NPARTS function. The condition is completed as follows: When the turning lane is full, the continuous driving there is to be block. Control of exit from the side street is protected by evaluating the occupancy of conveyor element C77. Its length is designed to fit a safe distance so that the vehicle can safely enter from the side road.

The object includes a car park with capacity of 20 places. The control method of parking is implemented by a two element machine. One element controls the entrance to the car park (machine003). Although the vehicles in the real system continue driving when the car park is full, in the simulation model, they are shipped from the system.

Way crossroad
The suitable combination of the element continuous queuing conveyor was used to design this object. The conjunction of conveyors supports the control of this crossroad simultaneously. The solution is presented in Fig. 5.

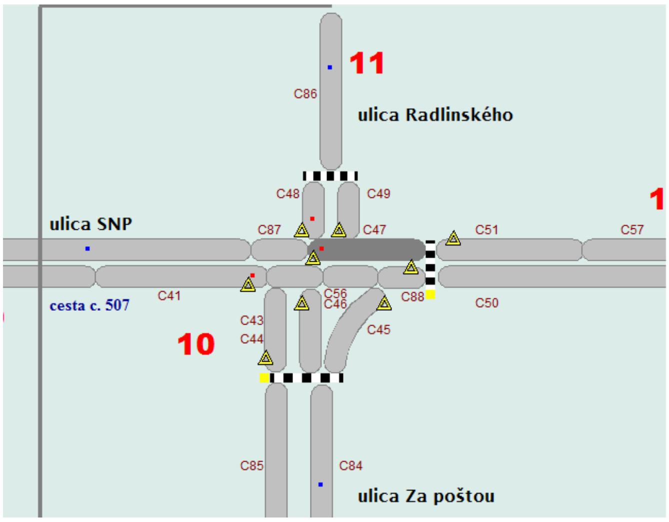


Fig. 5 *A four-way crossroad*

The solution to the crossroad control is similar to the previous types. The difference lies in respecting the traffic signs. The traffic sign does not allow trucks to turn to "Za poštou" street. The addition of the condition identifying the type of vehicle represents the solution to this problem. At this junction, it is also not allowed to turn to "Radlinskeho" street, which is one-way. The problem is solved as in the previous case.

Model verification and validation

The process of model verification tested whether the structure of simulation model is correctly represented (especially whether the requested parameters are defined and calculated correctly). The special types of vehicles named Tester1 and Tester2 were put into the model. These elements entered the model in 30-minute intervals, and their individual output values were recorded. These values were compared to the tested values from the real traffic system in the validation process. The tested vehicles represent the crossing of the city in the two most critical ways. The numbers of entered vehicles were set up to match the real system. The data gained from the model were compared to the data offered by the city major office.

Experimental

The individual experiments were designed in the way showing the reaction of the traffic system not only in the case of change in individual object of the traffic system, but also in the case of change in the combinations of more objects. We considered eliminations of those system elements causing the most delays while the changes are possible in the real system (1).

Experiment 1
The experiment included the elimination from one to four zebra crossings in the roundabout. All combinations were tested step by step.

Experiment 2
The experiment included the change or elimination of different individual objects e.g.:

- Turn restriction on the turning lane on the T-junctions at "M.R. Stefanika"
- Zebra crossing elimination on the side at "M.R. Stefanika" street
- No entry on the main road from the side of "M.R. Stefanika" street
- Pedestrian crossing elimination etc.

Seventeen experiments were carried out within this series. Every experiment required special model modifications.

Experiment 3
The experiment included the combinations of the best results from the previous experiments.

Attained results

A total of 54 experiments were done. The following output data were recorded from every experiment:

- Throughput time is the time of the vehicle passing through the city. To obtain the data, we used specially designed components called testers.
- Traffic delays on various roads in model. We used the road sections which are necessary to cross-pass the city.

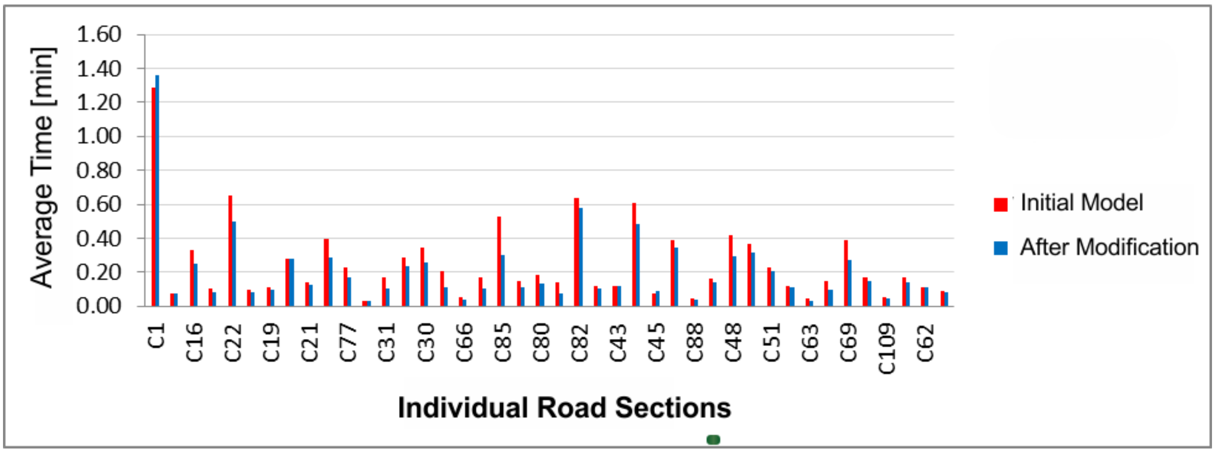
All output values were recorded into Excel. Then the gained data were compared with the results of the model that represents the current state.

The best result was achieved by the following modifications:

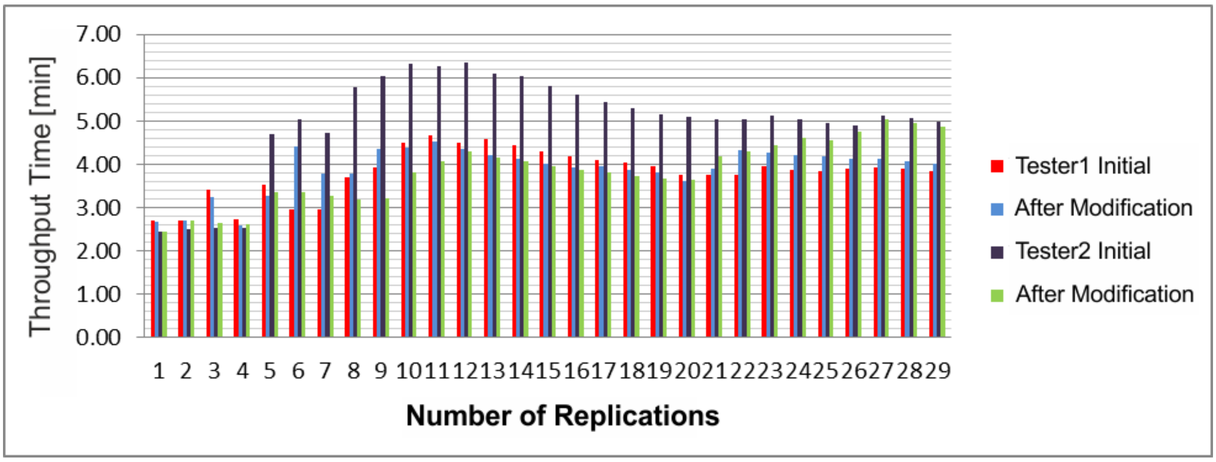
- Elimination of two zebra crossings on the roundabout (both are on the SNP street) and no entry on the main road from the "M.R. Stefanika" side street, and zebra crossing elimination on the side street "Namestie sv. Michala".
- All proposed remedies bring about 20% improvement of traffic over the current state
- Final solution is documented in the following graphs comparing the current state and the state after the traffic system modification.

The Graph 1 shows the time differences between the initial model (current state model) and the modified model for individual road sections of the city at the longest pass of the city.

The Graph 2 illustrates the results of tester's time representing the time needed for crossing city in both lanes (throughput time). We can see the improvement of the traffic on the basis of the evaluation of this type measured indicator on this graph.



Graph 1 *Average delay time on critical road segments*



Graph 2 *Throughput time for tested vehicles*

Conclusion

The goal of the research was to analyse the current state of traffic system in Hlohovec and identify the critical points of transport infrastructure. The simulation model of the traffic system was built in Witness 13c simulator of Lanner Group Ltd. on the base of the observed data from the real system. The identification of critical points of transport provides important data to detect the different sequence of events causing the traffic jams. The traffic system modifications were proposed by simulation support that can improve the traffic system in Hlohovec, especially reduce the time for passing through the city.

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