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THE CREATION OF MODELS OF ADJUSTABLE CROSSROADS ON GPSS

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The example of modelling of crossroads on GPSS (General Purpose Simulation System) is resulted in the article. By means of GPSS and language PLUS it is possible to develop models of rigid management, adaptive management and the mixed scheme of management. The developed models of rigid and adaptive management are compared on various streams. Models of crossroads in the subsequent can be connected in the certain scheme, characteristic a street network of a city, to carry out the analysis of work of whole city scheme with regulation on the basis of adaptive management, rigid management or the mixed scheme.

Keywords: *traffic light, adaptive steering, simulation*

Introduction

Before the start of working out, creation and application of any expensive system, it is necessary to make sure if there is a need for it. For this purpose the modelling is used. Modelling is the conventional means of knowledge of the reality. This process consists of two stages: working out of a model and the analysis of the developed model. Modelling allows investigating the essence of the complicated processes and the phenomena by means of experiments on model, instead of real object. For decision-making in the organization of system's work it is not obligatory to know all of the system's characteristics, the analysis of its simplified, approached representation is sufficient. The formal description of the logic of functioning of the investigated object, the character of interaction of its elements in time, which takes into account substantial cause-effect ties of the object, is necessary.

The Simulation Modelling

In the field of the creation of new systems modelling is one of the basic means of research. Simulation modelling becomes the main tool of comparison of various variants of operating decisions and search of the most effective of them. Imitation – the most powerful and universal method of research of the systems, which behaviour depends on accidental factors. The object is reproduced with the highest possible adequacy with preservation of the content and structure of elements, internal processes and character of their course in time. Simulation models are usually realized in the form of programs in terms of universal languages or modelling languages.

GPSS (General Purpose Simulation System) is one of the languages of the simulation modelling chosen for working out of the given model. It is concerned with number of task-oriented languages of modelling intended for the description and imitation of discrete objects. All standard aims of simulation modelling are automated (are hidden in the interpreter of GPSS). The system includes the entering language for the description of models and the task of modes of modelling and the corresponding software that provides the interface, modelling and statistical processing of results. Besides, there has been used the language PLUS (Programming Language Under Simulation) for realization of the block of management by phases. It is simple, but powerful programming language, which is the important part of the language GPSS. It gives the possibility to use the subroutines written on special syntax PLUS, in models and to receive the control over modelling performance that does language by even more flexible. It is possible to change parameters of the system and to carry out some blocks of the language GPSS in a global context of model.

At a construction of the model on the basis of the theory of mass service it is possible to present crossroads as a system with four serving devices and four streams of demands. The scheme is shown on Figure 1.

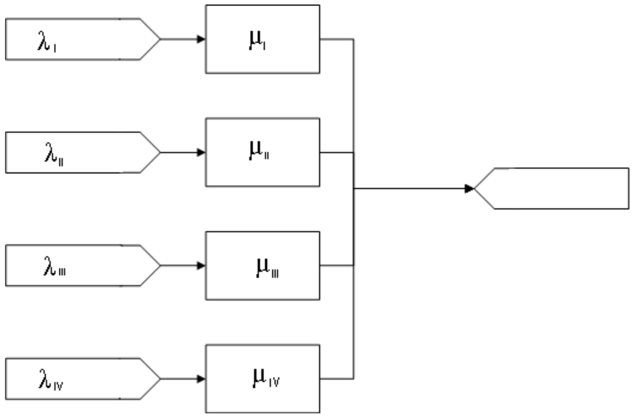

Figure 1. The Scheme of model of crossroads

Delay time in serving devices depends on duration of the traffic light phases, and also on transient time. Intensity of streams on roads varies not only during a day, but also has casual character as a whole.

With the purpose to develop the model more precisely it is possible to enter analogue of the road controller: the block of management of phases (figure 2). Thus, arriving demands in system first of all analyse a current phase and depending on it expect in turn, or pass further in serving device. In such kind of a model the role of the serving device consists of realization of the delay caused by the vehicles that pass through crossroads.

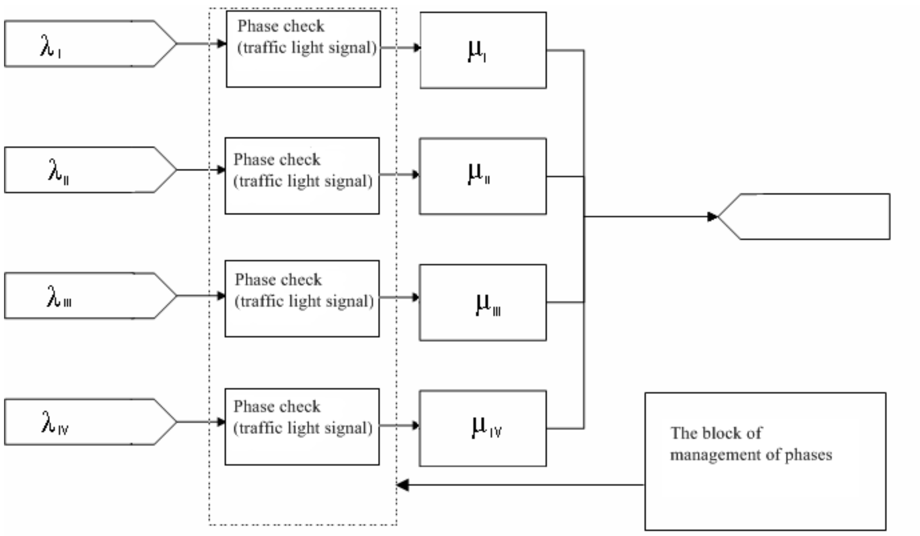

Figure 2. The scheme of model for GPSS

In the block of management of the phases lays the foundation of the logic of work traffic lights-object. If there is a rigid regulation the quantity of phases and their duration are set. If flexible – then the regulation algorithm key parameters are set. The realisation of the mixed scheme of regulation when flexible management covers not full number of directions is quite possible.

Results of Simulation

The diphase, three-phase and four-phase models of traffic lights-object (TLO) with rigid and adaptive management have been realized. Testing has been set on streams with various intensities.

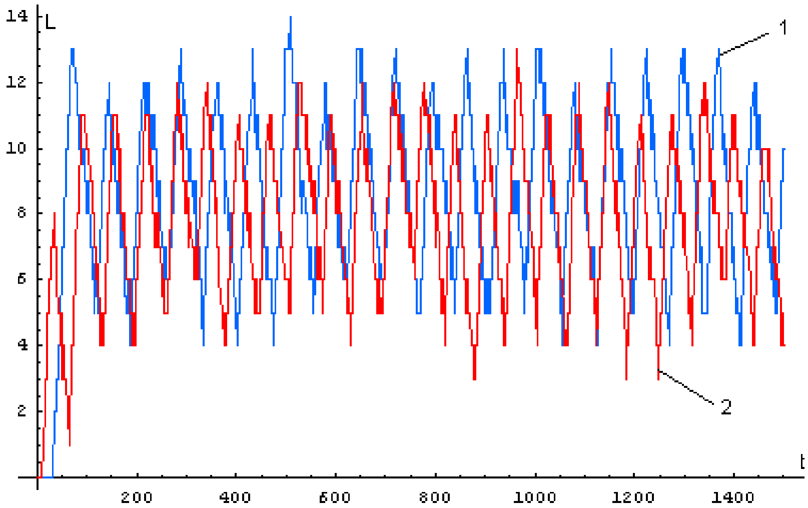

Figure 3. The schedule of dynamics of length of turn for diphase TLO

On Figure 3 dynamics of change of length of turn in the first direction for TLO with rigid regulation (1) and flexible (2) are represented. The intensity of streams of 1200 buses/hour is equal in all directions. Under the schedule it is visible that the difference between regulation modes is not considerable. A prize of flexible regulation only is in the account of short-term fluctuations of suitable vehicles.

The statistics collected GPSS is presented in Table 1 and Table 2.

Table 1. Statistics of turns for diphase TLO with rigid regulation

№ Direction	Intensity of a stream, buses/hour	The maximum length of turn, bus	Average value of turn, bus	Average waiting period, second
1	1200	15	9	27.17
2	1200	15	8.9	26.76
3	1200	15	9	27.13
4	1200	15	8.87	26.71

Table 2. Statistics of turns for diphase TLO with flexible regulation

№ Direction	Intensity of a stream, buses/hour	The maximum length of turn, bus	Average value of turn, bus	Average waiting period, second
1	1200	14	7.98	23.9
2	1200	14	7.93	23.76
3	1200	13	7.97	23.89
4	1200	13	7.89	23.65

For the analysis of turns we will change intensities on peak in one direction and in others on 900 buses/hour. The statistics collected GPSS is cited in Tables 3, 4. At a flexible regulation TLO aspires to equal an average waiting period. The advantages of flexible regulation are more notable in the maximum length of turn in comparison with rigid regulation.

Table 3. Statistics of turns for diphase TLO with rigid regulation

№ Direction	Intensity of a stream, buses/hour	The maximum length of turn, bus	Average value of turn, bus	Average waiting period, second
1	1800	31	21.46	43.13
2	900	11	5.32	21.22
3	900	11	5.22	20.86
4	900	12	5.33	21.24

Table 4. Statistics of turns for diphase TLO with flexible regulation

№ Direction	Intensity of a stream, buses/hour	The maximum length of turn, bus	Average value of turn, bus	Average waiting period, second
1	1800	26	20.18	40.4
2	900	15	9	35.96
3	900	10	2.2	8.76
4	900	15	9	35.99

It is visible that in the direction 3, which is enclosed in one phase with the direction 1, the turn is small also an average waiting period less in comparison with other directions. At the given streams it would be possible to use a three-phase mode of regulation with flexible regulations, for equalizing the congestion of a crossroads in all directions.

On Figure 4 the dynamics of length of turn in time for three-phase TLO with rigid regulation (1) is shown and flexible regulation (2), on the same intensities, like in the previous experiment is represented.

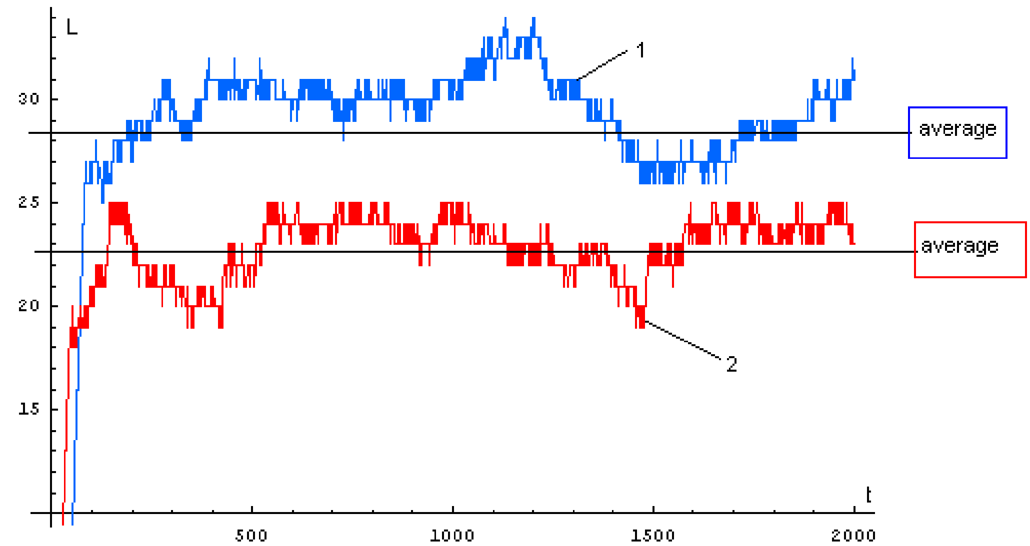

Figure 4. The schedule of dynamics of length of turn for three-phase TLO

To the given experiment there corresponds the statistics represented in Tables 5, 6.

Table 5. Statistics of turns for three-phase TLO with rigid regulation

№ Direction	Intensity of a stream, buses/hour	The maximum length of turn, bus	Average value of turn, bus	Average waiting period, second
1	1800	34	28.58	57
2	900	17	10.5	41.8
3	900	17	10.3	41.56
4	900	17	10.17	41.1

Table 6. Statistics of turns for three-phase TLO with flexible regulation

№ Direction	Intensity of a stream, buses/hour	The maximum length of turn, bus	Average value of turn, bus	Average waiting period, second
1	1800	26	22.52	45.35
2	900	20	11.84	47.41
3	900	22	14.86	53.75
4	900	20	11.87	47.34

The statistics shows that flexible management equalizes an average waiting period of the vehicles in all directions, reduces an average length of the turn in the loaded direction with the help of other directions with no-saturated streams. Thus, if the stream is over-saturated, the turn at flexible regulation grows much more slowly in comparison with the rigid.

On Figure 5 the dynamics of length of turn in time for four-phase TLO with rigid regulation (1) is shown and flexible regulation (2), with intensity in the direction 1 1200 buses/hour is represented and in other directions 900 buses/hour. The four-phase TLO are used basically for large crossroads.

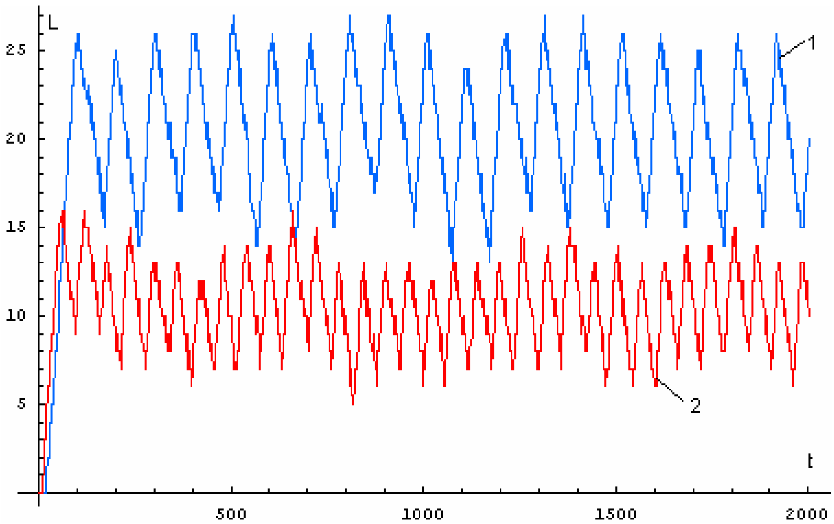

Figure 5. The Schedule of dynamics of length of turn for four-phase TLO

The statistics for four-phase TLO is represented in Tables 7,8.

Table 7. Statistics of turns for four-phase TLO with flexible regulation

№ Direction	Intensity of a stream, buses/hour	The maximum length of turn, bus	Average value of turn, bus	Average waiting period, second
1	1200	28	20.1	60.46
2	900	21	13.54	53.89
3	900	22	13.28	53.01
4	900	22	13.38	53.45

Table 8. Statistics of turns for four-phase TLO with flexible regulation

№ Direction	Intensity of a stream, buses/hour	The maximum length of turn, bus	Average value of turn, bus	Average waiting period, second
1	1200	17	10.54	31.68
2	900	15	8.88	35.54
3	900	14	8.7	35
4	900	13	8.58	34.2

It is visible that the advantages of adaptive regulation are considerable in comparison with the rigid for such kind of TLO. Also the average waiting period, as well as average value of turns, in all directions at adaptive regulation is equalized most precisely.

The Basic Conclusions

1. At identical streams (no saturated) of vehicles similar results show correctly adjusted rigid and adaptive management.
2. At increasing stream of the vehicles in some directions, adaptive management operatively reacts and changes duration of phases, allocating more time for directions with more intensity.

3. At over-saturated streams of the vehicle, lengths of turns constantly grow, but at adaptive management this growth is slowed down in comparison with rigid regulation.
4. However adaptive management aspires to equalize lengths of turns in all directions that causes the growth of turns and the waiting period from a no-saturated stream, and conducts to additional complexities, in such cases it makes sense to consider the mixed algorithms of management.

References

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