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SIMULATION APPROACH TO LOGISTIC SYSTEMS SYNTHESIS

Many problems in the logistic field have a stochastic characteristic and to create the mathematical models is very difficult e.g. the city transport, where intervals of arrival cars to the crossing are stochastic, or production time in manufacturing company depends on many factors. In these cases could be a solution for the creation model of these processes of simulation. This paper describes the methodology of the creation the simulation model and its application on logistic systems synthesis.

1. INTRODUCTION

System can be analyzed and designed:

a) on a real object
b) on a physical model
c) on mathematical model
d) on heuristic model
e) on simulation model.

The simulation is a synthesis method where designed LS is replaced by a simulation model, with which all are carried out, with the aim of achieving parameters that are later applied back on examined and designed LS.[1], [1]

Simulation is one of the last and most expensive alternatives for LS synthesis. Due to the complexity, stochasticity and variousness of processes; simulation is often the only option for LS synthesis. [1]

E.g. in case of a very complicated crossing

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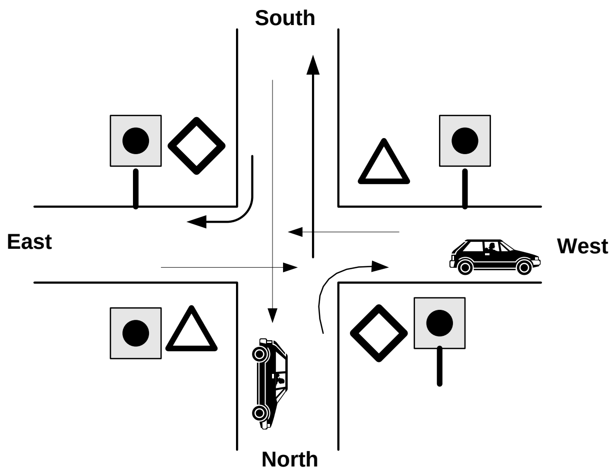


Fig. 1. The crossing as LS

E.g. if an objective and task is defined: to find an optimal length of green lights in all directions so that cars wait at the crossing as short as possible and so that the crossing has the maximal operating efficiency. [1]

Density and conveyance flows are different during peak, times during nights of weekends, during holidays or during different seasons.

A particular crossing could be observed and set directly on the real crossing but that would be unrealistic.

However the crossing can be modeled – we create a physical model with cars and lights, which is a possible task but only visionary for calculation of essential parameters (τ_s, τ_j, τ_v, τ_z – times of green lights from the north, south, east and west).

This is a possibility to create a mathematical model based on systems for bulk service. The task is feasible but a model of four or six systems for bulk service interactively excluding each other activities is extremely complicated.

In this case simulation would be the only solution. A simulation model for a particular crossing will be created and on this model, experiments will be performed (different lengths of green lights). Status of each of the cases will be carefully monitored. From several variants only one – optimal will be selected and applied to the real crossing.

Nowadays only computer simulation models play an important role in the real praxis.

Simulation models are functional models which copy the functions, activities and processes of a real LS. In our case we are not modeling a crossing but its functions, e.g. cars come to a crossing, if there is a red light, they wait, if there is a green light, they pass, etc. Such creation of a simulation model requires a specific analysis described during creation of simulation model. [1], [1]

Simulation models of LS are mostly discrete, respectively they can be defined as discrete systems. [1]

2. THE STEPS SEQUENCE IN SIMULATION MODEL DESIGN FOR LOGISTIC SYNTHESIS

The steps sequence for the simulation model design can be described in fourteen steps [1]:

1. **Problem definition** is e.g. wrong function fulfillment; low performance of a shipping system, long waiting duration at the crossings, violation of delivery dates, overload of intermediate operation buffers, efc. objective definition follows the problem definition. E.g. to find an optimal length of a green light at the crossing, dinf tight place of a manufacturing process, design optimal capacity of intermediate operation buffers, etc.

2. If a particular object (a company, crossing, conveyance system) exists, we **define a system** on it (a LS) on which we would like to verify a topology, elements parameters, transmittance, capacity utilization – variables: times, position, capacity.

   If a real system doesn't exist, we have to conclude from its project, design, meaning **simulation model assumes the existence of projected system in real or project form**.

3. **definition of variables** for simulated model, what characterize particular LS (τ_s, τ_j, τ_v, τ_z, – time durations from the north, south, east and west), P – transmittance, etc..

4. synthesis assignment is a transformation of **defined LS into a system of bulk service** respectively other formalized system we are able to model by a particular simulation tool (language, system). e.g. a crossing is pictured as six simple bulk services of which two or three can work simultaneously. The others are interlocked. E.g. a crossing is transitive in directions S→ N and N→S, other directions are interlocked.

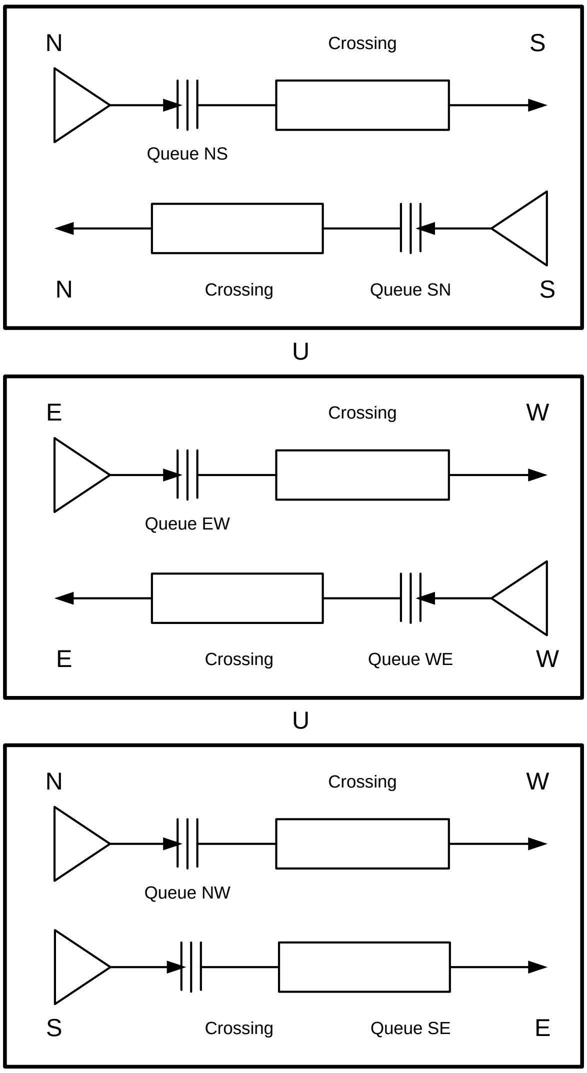


Fig. 2. Model of a crossing as bulk service system

5. **Selection of simulation tool – a simulation system for model cretaion**. It can be – a universal language e.g. Pascal, C++, however a creation of simulation model is more complicated; or it could be one of block-oriented simulation languages e.g. GPSS, SIMAN, or one of iconic languages SIMFACTORY, EXTEND, which are necessary to be skilled in but a model creation is significantly easier. This is the only disadvantage of simulation model synthesis, because the designer must be skilled in at least one of the simulation languages or other tools.
6. **Creation of global simulation model** – conceptual simulation model – which the element of a real system will be modeled by what element or tool of simulation lan-

guage, e.g arrival of cars at the crossing will be modeled by generating random numbers in GPSS represented by GENERATE block, in SIMANE by CREATE block; machine operation will be modeled in GPSS by orders:

- SEAZE CROSS
- ADVANCE T_1, T_2 (processing time, processing time dispersion)
- RELEASE CROSS,

Such modeling will be carried out by other blocks in SIMFACTORY, and others in SIMAN etc.

Steps 5 and 6 are the most creative, they are the center of the synthesis and require abstract, creative way of thinking, knowledge in philosophy of object programming.

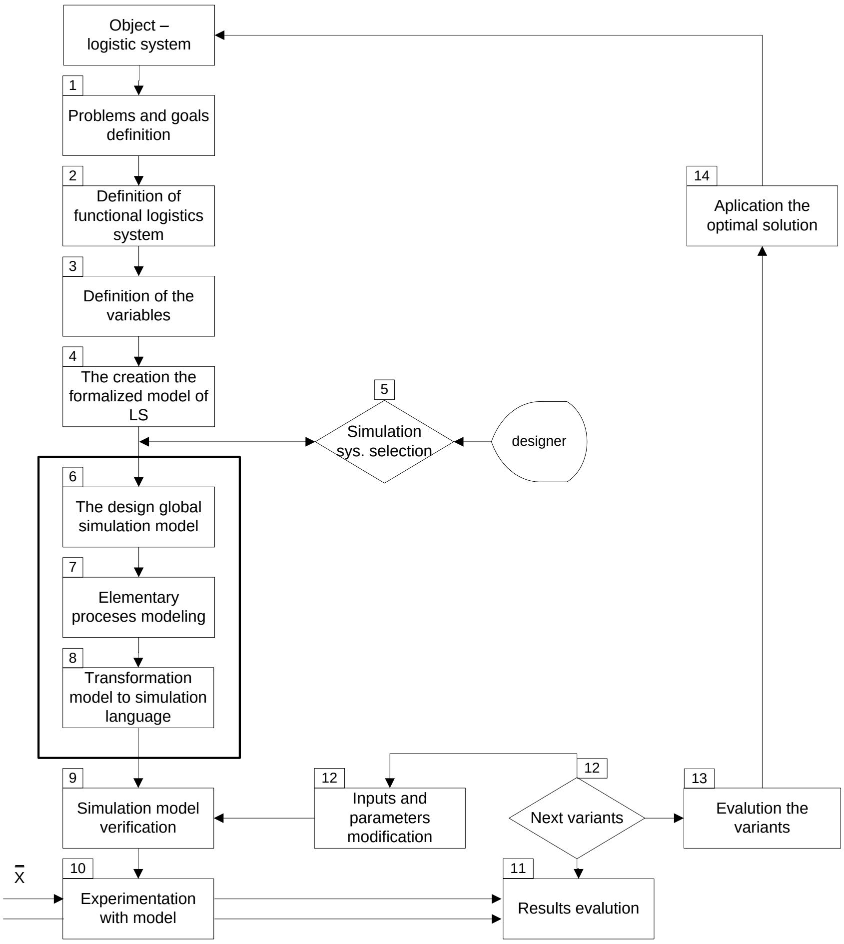


Fig. 3. Sequences of steps during LS synthesis with SM

7. **Creation of models, elementary processes and definition of parameters, functions and blocks:**
   - Division of a model into elementary components – inputs, array, machines, buffers, dividing, cumulating, quality control, etc.,
   - Generating of random numbers (modeling of inputs, orders, violation),
   - Process synchronization,
   - Time control in simulation model (TIMER),
   - Gathering locations and evidence of results in the model,
   - Output definition – variables and their functioning.
8. **Transcribing of model into command of simulation language** – creation of simulation model (according language type).
9. **Verification of simulation model:**
   a) From a logistic point of view – if processes in the real system perform the same way as in the model, if a model truly reproduces the behaving and functions of the real system,
   b) From a formal point of view – if syntax of used language is ensured
   Till the logistical correctness must be controlled by particular controlling steps by a designed (e.g. model flows control, their directions and capacity), formal point of view which is controlled by a selected language compiler – simulation system.
10. **Experimentation with model – Simulation** is time that passes by during the model experiments or duration of simulation model compared to the real time. The essential question is how long is required to simulate a real system so that results (proceed statistically) can be approved as valid for a designed LS. Due to the complexity of LS relations, very often there is no possibility to define a simulation time. But the more precise results we want to achieve, the longer simulation time is required. There is one simple rule. Simulation is performed when

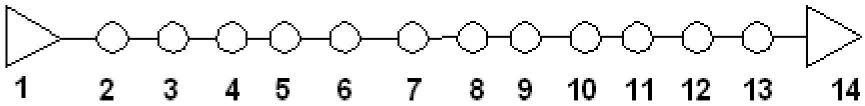
$$\left| x_i - x_{i+n} \right| \le p$$

This means, that the difference of variable x_i values during *i* experiments and $i + n$ experiments is smaller than defined precision – *p.* If required precision was achieved during experiments, simulation can be finalized.
11. **Evaluation and result calculation**. From the experiment with simulation models are collected the elementary data for the calculation the defined variables.
12. **Experiment iteration with another variant**. When simulation model is created, it can be used for more than one variant. The simulation approach of the logistic system synthesis allowed to find not only a solution, but good one optimal solution. This is reason for changing the inputs in data and model parameters and to simulate next variant.
13. **Variant evaluation and selection of optimal solution**. After the simulation the set of variants by define criterion (e.g. minimum waiting time, maximum number of cars with pass the crossing,…), is an optimal variant of the solution selected.
14. **Application of a solution to a real system**. Result of simulation is applied to the researcher object – logistic system.

3. THE TREND IN SIMULATION SYSTEMS DEVELOPMENT

Evolution of simulation tools, languages and systems leads to a creation of client-oriented simulation systems.

When all processes during analysis and synthesis of simulation models are pictured in the sequence figure.



There can be defined four generation (levels) of simulation tools by the number and level of realized steps in simulation model design. [1]

E.g.

1) By applying PASCAL, FORTRAN, C++, … , general languages, the designer executed all 14 activities in the synthesis of LS.

2) XXX is applying GPSS (Block-oriented simulation systems) designer executes activities 1, 2, 4, 5, 6, 8, 9, 11, 12, 13, 14 and GPSS activities 3 and 10.

3) By using SIMAN, designer realized activities 1, 2, 4, 5, 6, 13, 14 and SIMAN (Interactive simulation system) activities 7, 11, 8, 9 comunication with designer.

4) Application the EXTEND – the object-oriented simulation systems, the designer have to realized activities 1, 2, 5, 13, 14 and simulation system by comunication with other designers. [1]

For modeling logistic system are most often applied discretely - object oriented simulation system, a.g. SIMFACTORY, EXTEND, ARENA, WITNESS, SIMPLE ++. [1]

4. CONCLUSION

In this article is described the methodology for creation the simulation model the logistic systems of the discrete character. This paper described individual steps for simulation model creation, verification and application, when are applied the simulation systems. In the paper are compare activity of the designer with application different generation of simulation languages.

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