firm car service, simulation experiment

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THE SIMULATION EXPERIMENT AS A MEANS OF THE TRANSPORT SYSTEMS OPTIMIZATION

Summary. In the article the matters connected with the firm service system optimization using the simulaiton experiment are shown. It is analyse in short by the results of computer experiment execution, and useful guidelines are given.

EKSPERYMENT SYMULACYJNY JAKO INSTRUMENT OPTYMALIZACJI SYSTEMÓW TRANSPORTOWYCH

Streszczenie. W artykule przedstawione zostały zagadnienia związane z możliwością wykorzystania eksperymentów symulacyjnych do optymizacji systemów transportowych na przykładzie przedsiębiorstwa usługowego. Analizie zostały poddane wyniki eksperymentów symulacyjnych, które posłużyły do sformułowania wniosków.

1. INTRODUCTION

The modern enterprise, including the dealer-service centre, should depend on personal qualities of the head (professionalism, mobility, erudition, etc.) as less as possible, because the guarantee of stability and sustainable development consists of the objective characteristics of its functioning: the co-ordinated work of all divisions and services, and also validity and objectivity of acceptance of administrative decisions. Modern IT technologies give the chance to create such systems, in which the results of spent analysis of situations on mathematical or simulation models is a basis of one or other administrative influences. Advantage of such approach consists in those models are made with taking into account experience of the previous periods, the set of factors and their combinations, that allows to choose, finally, an optimum variant from sets of possibilities.

Now there is a set of the researches devoted to modelling of different processes, both industrial character and queuing systems. In such models certain process with its internal parameters and external influences is considered, optimum characteristics for concrete conditions are out. Such decisions are present for objects of industrial sphere (simulation models), systems of material support (storekeeping model, warehouse logistics, models of deliveries chains management), that is represented in Moore, Weatherford and Hamdy [1, 2], etc.

The problems solved by the enterprises of firm automobile service are represented in fig. 1. Apparently from the given scheme, management and optimisation of aims of each zone demands to use the adequate mathematical models which application makes it impossible in real conditions without corresponding toolkit - the information technologies, allowing to make difficult calculating processes. It is possible to define some classes of the problems solved by various services of the dealer-service centre. Mathematical models and tools for their realisation in the firm automobile centres are represented in tab. 1.

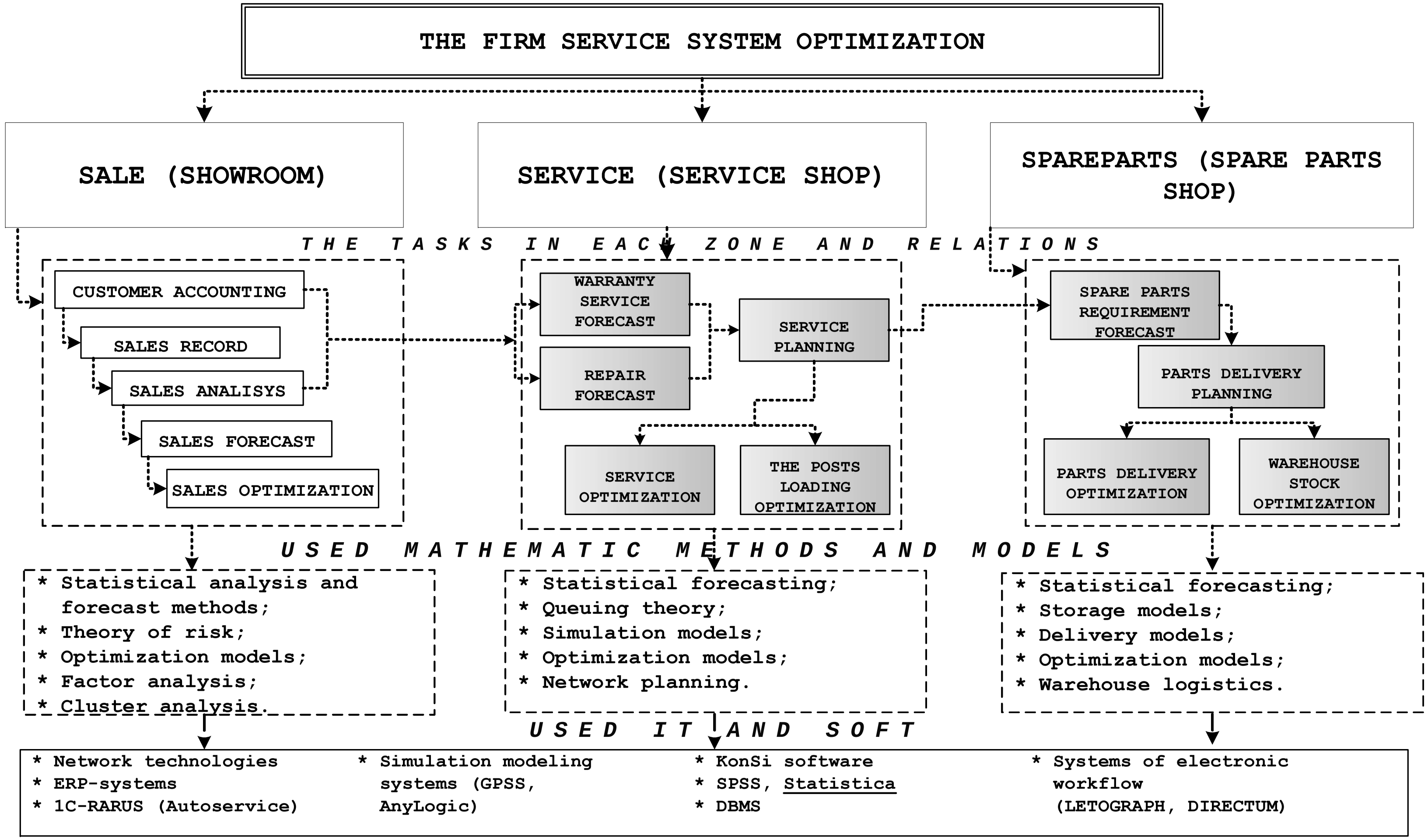

Fig. 1. Mathematic models and IT using in firm service system
Rys. 1. Modele matematyczne i technologie informacyjne w przedsiębiorstwie usługowym

Table 1

Mathematical models as management tool of the firm automobile centre activity

Problem	**Mathematical model**	**Decision data support**
The analysis of sales market, the analysis of services market, the forecast of sales and services	The risk theory, cluster analysis, the factorial analysis, the SWOT-analysis, benchmark	Marketing researches packages of firms ALT, KonSi
Forecasting of service services and spare parts requirement	Statistical factorial and regression models	Statistical packages Statistica, SPSS, etc.
Scheduling on cars service	Models of network planning and management	Specialised packages MS Project etc.
Optimization of service and posts loading	Queuing systems, simulation models	Simulation modelling packages: GPSS, AnyLogic etc.
Planning of support repair posts with spare parts	Transport problem, storekeeping models	Mathematical packages MathCad, Maple, MatLab

Widespread method of prognostic modelling is simulation modelling. It is connected by that the majority of real objects owing to complexity, discrete character of separate subsystems functioning cannot be described adequately only by means of analytical mathematical models. The simulation model allows to use available information without dependence from the form of its representation and formalisation degree. The simulation model is built by sample and according to the structure of forecasting object. [3]

2. PROBLEM DEFINITION

The following problem is represented as an example of optimisation of the firm service centre activity.

The firm car service centre is considered as multichannel queuing system with turn, on which the elementary stream of requirements arrives. The stream of requirements is divided into four kinds, proceeding from a priority of the service organization, among which there are cars attributed to the given dealer centre and served constantly - among them leasing cars have the highest priority, then the cars which are in warranty service, then being in regular operation, and, at last, transit, not attributed to the given dealer centre. According to algorithm, cars pass only one of two kinds of works: maintenance service or operating repair. Frequencies distribution of allocation of kinds of request is shown in table 2.

Table 2

Frequencies distribution by kinds of request

Kind of requirement	Priority	Frequency of each request	Work type	Frequency of each work
Service of leasing cars	1	0,10	Maintenance	0,3
			Repair	0,7
Guarantee service	2	0,25	Maintenance	0,3
			Repair	0,7
Service of transit cars	3	0,05	Maintenance	0,7
			Repair	0,3
Service in regular operation	4	0,60	Maintenance	0,7
			Repair	0,3

Arrivals can be serviced by the maintenance posts of two kinds, the maintenance post and the repair post, which are multi-purposed by the spectrum of operating jobs. The service time on such posts is set by distribution law, which is determined on the basis of statistic analysis.

Besides, during the guarantee maintenance the certificate of compliance is transferred to the maker of the faulty unit, after that the protocol is expected, and it takes a certain time. The waiting time depends on accepted by enterprise workflow system. Paper workflow the guarantee maintenance lasts on average about 10 hours; at the electronic workflow this quantity is equal to 1 hour.

It is necessary to determine such characteristic of service system, when the length of the maintenance queue is minimal.

3. SYSTEM SIMULATION

As a means of the model development the applied program package, modern Russian professional toolset AnyLogic for simulation was chosen. The advantage of the toolset consists in the used OO technique, which allows to organize and present the structure of complicated system so simply and naturally.

The automotive firm service system research with using of simulation models is represented by organizing and running the computer experiment. In such case the rational decision is usually choosing from the solution set, and such decision maximize expected benefit and profit. The decision is always chosen in compliance with some criterion, in other words besides X and Y factors the efficiency index W is introduce. This index may be computed by the output vector Y and is representing the quality rating of making decisions. The Φ function (from the Y set of resulting indexes into the W set of estimated model quality):

$$Y \xrightarrow{\Phi} W \tag{1}$$

evaluates each possible vector of resulting indexes. Thus, the inverse problem of simulation is decided, after that the most preferable alternate solution is found, when the efficiency index turns into the maximum [4, 5].

The general arrangement of the simulation experiment is represented in fig. 2.

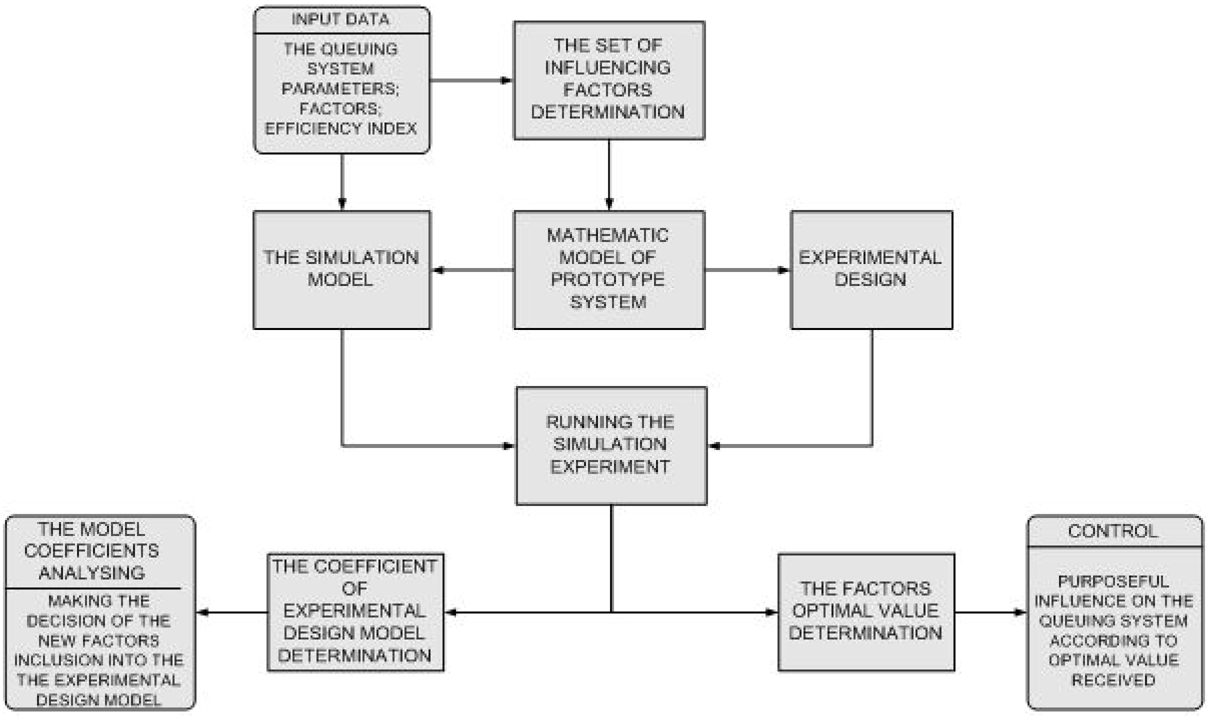

Fig. 2. The general arrangement of the simulation experiment
Rys. 2. Struktura eksperymentu symulacyjnego

It is necessary to determine the next parameters before the running of computer simulation experiment.

- **Amount of model executions**. As the research will be passed according to the full- factorial plan, the amount of model executions is equal to $2^3 = 8$.
- **Time stop**. As the period of simulation is accepting equal to 1 year, the count of modeling units time for one run is equal to $(18-8)\cdot 5\cdot 52 = 2550$ (according to that one modeling unit time is equal to 1 hour of real time, the duty of a dealer-service centre is from 8 a.m. till 6 p.m. in five hour per week, at the same time the count of weeks per year is equal to 52).
- The **objective function** (Y) is a mean value of demand servicing time in the system.
- The **model parameters** are: the count of service posts (X_1), mean value of one post workers (X_2), the time to transfer the certificate of compliance to firm-producer (X_3).
- The **limitations of model** are: the time of the service posts downtime and the downtime of every worker on the post; this value is aiming at 0: $U(X_1) \to 0$; $V(X_2) \to 0$.

Thus, the simulation experiment in the optimization experiment in the simulation system AnyLogic is executed. The description of the experiment is represented in fig. 3. As a method of optimization the built in optimizer OptQuest based on the Tabu search methods is used [66, 7].

After running the series of experiments based on simulation model the data for each combination of factors according to the full-factorial plan was estimated; as the factors values the boundary value. The set of objective values which was found with the series of experiments is represented in fig. 3.

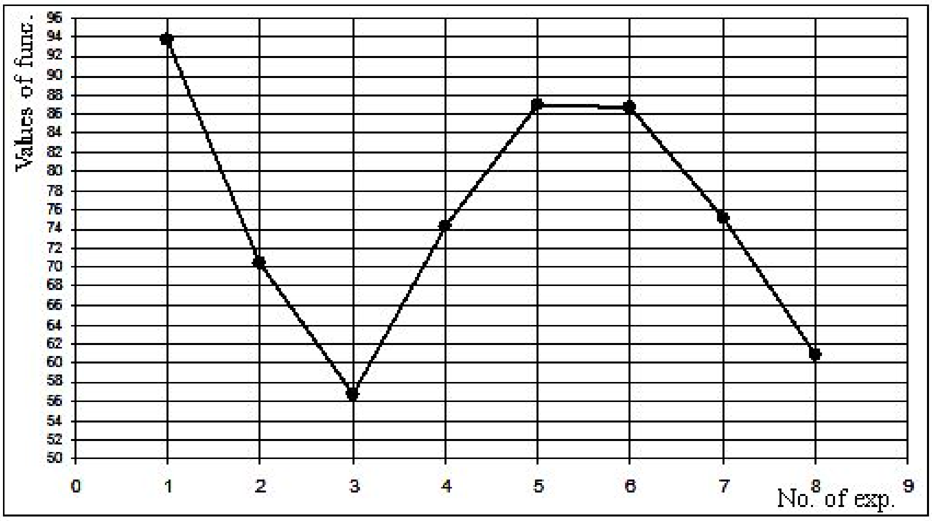

Fig. 3. The values of the objective function
Rys. 3. Wyniki eksperymentów symulacyjnych jako wartości poszukiwanej funkcji

The result of each experiment tabulates where the values of factors, objective function are shown, and the constraint satisfaction is analyse.

4. CONCLUSION

Thus, the simulation optimizing experiment shown that the most effective is the next maintenance organization (when the value of objective function Y is minimally, constraints are satisfactory):

- The count of posts is equal to 10 (X_1 factor);
- The count of workers on each post is equal to 3 (X_2 factor);
- The enterprise accepts the electronic workflow (X_3 factor).

Table 3

The results of experiments performing
on the simulation model

X_1	X_2	X_3	Y	Constraint satisfaction
10	1	1	93,74	Yes
14	1	1	70,40	No
10	3	1	56,79	Yes
14	3	1	74,32	No
10	1	10	86,94	Yes
14	1	10	86,75	Yes
10	3	10	75,10	No
14	3	10	60,93	No

References

1. Moore J.H., Weatherford L.R.: *Decision Modelling with Microsoft Excel*. Upper. Saddle River, NJ: Prentice Hall, 2001.
2. Hamdy A.T.: *Operations research: an introduction*, Prentice Hall, 2002.
3. Law A.M., Kelton W.D.: *Simulation modeling and analisys.* 3rd edition, McGraw Hill Higher Education, 2000.
4. Ross S.M.: *Simulation, (Statistical Modeling and Decision Science).* 3rd edition, Academic Press, 2002.
5. Banks J. ed.: *Handbook of Simulation, Principles, Methodology, Advances, Applications, and Practice.* J. Wiley & Sons, Inc., 1998.
6. Glover F. ed.: *Tabu search methods for optimization*. Feature Issue of European J. Oper. Res. V.106, № 2–3, 1998.
7. Laguna M., Marti R.: *Scatter Search: Methodology and Implementations in C*, Kluwer Academic Publishers, Norwell, MA, 2002.

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