O. O. Kovalyuk

INFORMATION TECHNOLOGY OF DECISION MAKING IN DISTRIBUTED DYNAMIC SYSTEMS OF CONTROL

Information technology of decision-making in distributed dynamic systems control is suggested, it enables to improve the quality of decisions by taking into account the interaction between the elements of the system and uncertainty of the input data.

Key words: *information technology, decision-making, distributed system.*

Introduction

The problem of distributed dynamic systems (DDS) control does not lose its actuality over time. Distributed dynamic systems is a broad class of systems, elements of which are distributed in space and perform some functions that provide attainment of the overall objective the system is designed for.

Main characteristics of DDS are:

- availability of system elements their own criteria for decision-making;
-delays while transfer information and control impacts between elements of the system;
- uncertainty of system parameters that can be described using different approaches depending on the mode of obtaining information (measurements, expert evaluation) [1];
- hierarchical structure of the system.

These systems include gas pipelines, systems of water, heat supply, transport networks, processes of storage products, etc. Taking into account these features of distributed dynamic systems, it becomes apparent the complexity of decision making to control the operation of such systems.

Analysis of approaches to the solution of decision-making problem for DDS control

One of the first fundamental results obtained as a result of distributed systems study belongs to Mesarovych and his colleagues [2]. In these works mathematical apparatus for description of complex distributed systems is suggested. Much attention is paid to the formalization of systems and coordination of their subsystems. However, despite the importance of these works, they are quite general, that is why a number of issues were not considered by the researchers. Particularly, methods of accounting uncertainty associated with systems functioning have not been considered profoundly; evaluation of influences change between the subsystems is not investigated. Another common approach to decision making in distributed systems is usage of game theory [3]. However, the use of game theory to decision-making has found limited application because of the complexity of systems dynamics account. Recently theory of active systems is intensively developed, the main idea of which is presentation of the system in the form of hierarchical agents, interacting with each other [4]. This theory finds application in the management of socio-economic systems: projects, organizations and administrative units. However, formalization of interaction between the elements of system can be rather complicated process that restricts the application of the theory of active systems for decision-making in DDS. Thus, the problem of decision-making while performing control functions in DDS is an actual problem and requires the elaboration of decision-making information technology, that would take into account the uncertainty and dynamics of distributed systems.

Solution of the problem of decisions quality improvement in the process of DDS control

To improve the efficiency of control decisions we will elaborate information technology (IT) of decision-making in the process of DDS control.

Architecture of decision-making information technology in the process of distributed dynamic systems control

According to State Norms information technology – it is a set of methods, techniques, aimed at usage of computational facilities to perform collection, storage, processing, transmission and application of data. Architecture of decision-making IT in DDS is presented in Fig. 1.

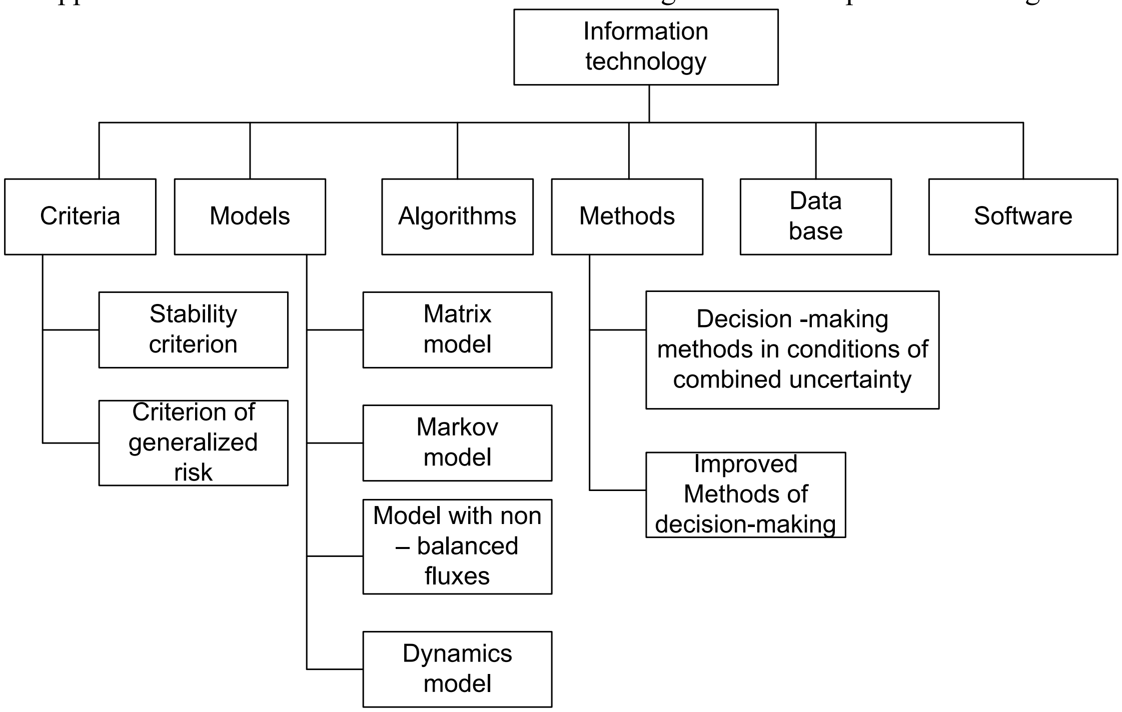

Fig. 1. Architecture of decision-making information technology for DDS

The main elements of the proposed architecture are criteria, models, algorithms, methods of decision-making and their implementation in the form software and databases. Let us consider some of the elements of IT.

Models of information technology

IT of decision-making for DDS control involves complex models, the connection between them is shown in Fig. 2. In IT of decision-making two groups of models are used: model of distributed system and models of decision making. Model of distributed system consists of models that describe the structure of the system, behavior and interaction of its elements. Second group of models correspond to models that are used in algorithms for decision making. Functional models of elements in the operator form describe the behavior of the element in conditions of uncertainty of its parameters. Form of operator transformations is determined by the model of uncertainty, which defines the method of performing mathematical operations for data represented in different forms. The structural model describes the links between elements of the system. For a large number of distributed systems, structural model is based on graph models and is presented in matrix form. Model of elements interaction is intended for evaluation of the impact between the elements of the system to determine their state at the time of decision making. Using these models at appropriate stages of decision-making process allows to obtain input data for models of the next stage.

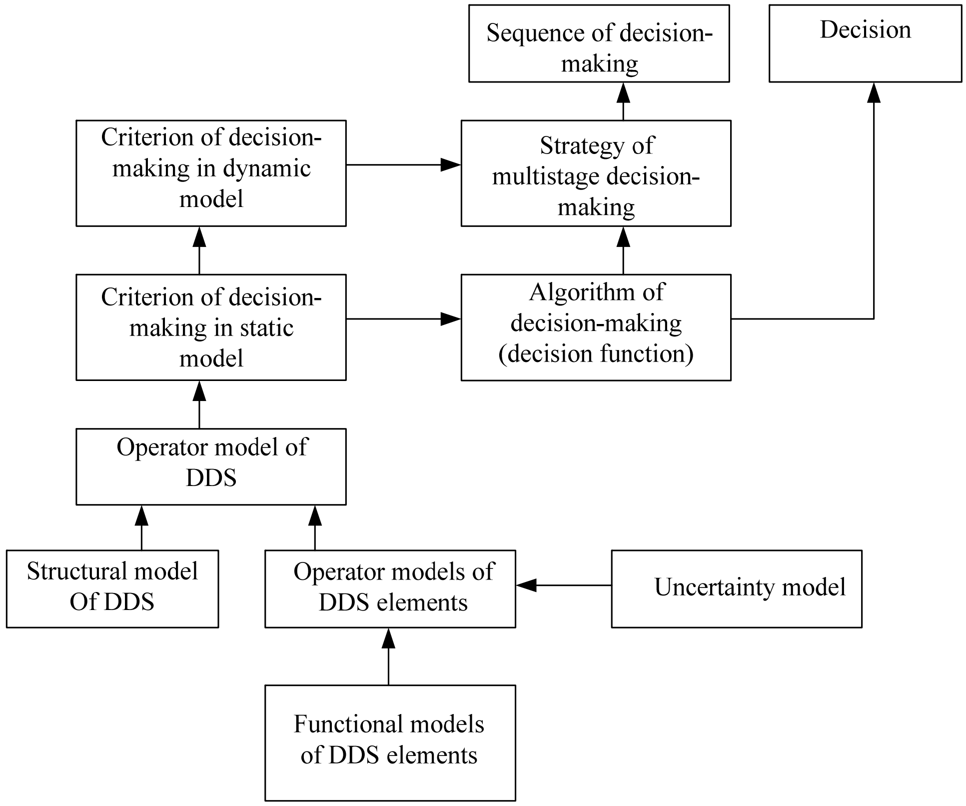

Fig. 2. Hierarchy of decision-making model

Generalized algorithm of decision-making for DDS control

The proposed IT includes algorithmic support of decision-making process. Generalized algorithm for decision making of DDS control process consists of the following steps:

1. Determination of the list of parameters that are required to provide the given quality of decisions.
2. Determination of parameters of distributed system state, subjected to observation.
3. Determination of frequency of each value control.
4. Obtaining of expert data regarding the parameters which can not be monitored.
5. Submitting of obtained data in the form of generalized functions of uncertainty [5].
6. Solution of the problem of state parameters estimation, regarding which neither experimental nor expert data are available, based on the model of distributed system.
7. Definition of the set of possible decisions by solving the problem of analysis of distributed systems stability.
8. Obtaining of losses function for the set of possible decisions.
9. Search of optimal solution that provides minimum losses.
10. Correction generalized functions on the basis of observation data.

Realization of the generalized algorithm using similar approach is shown in Fig. 3.

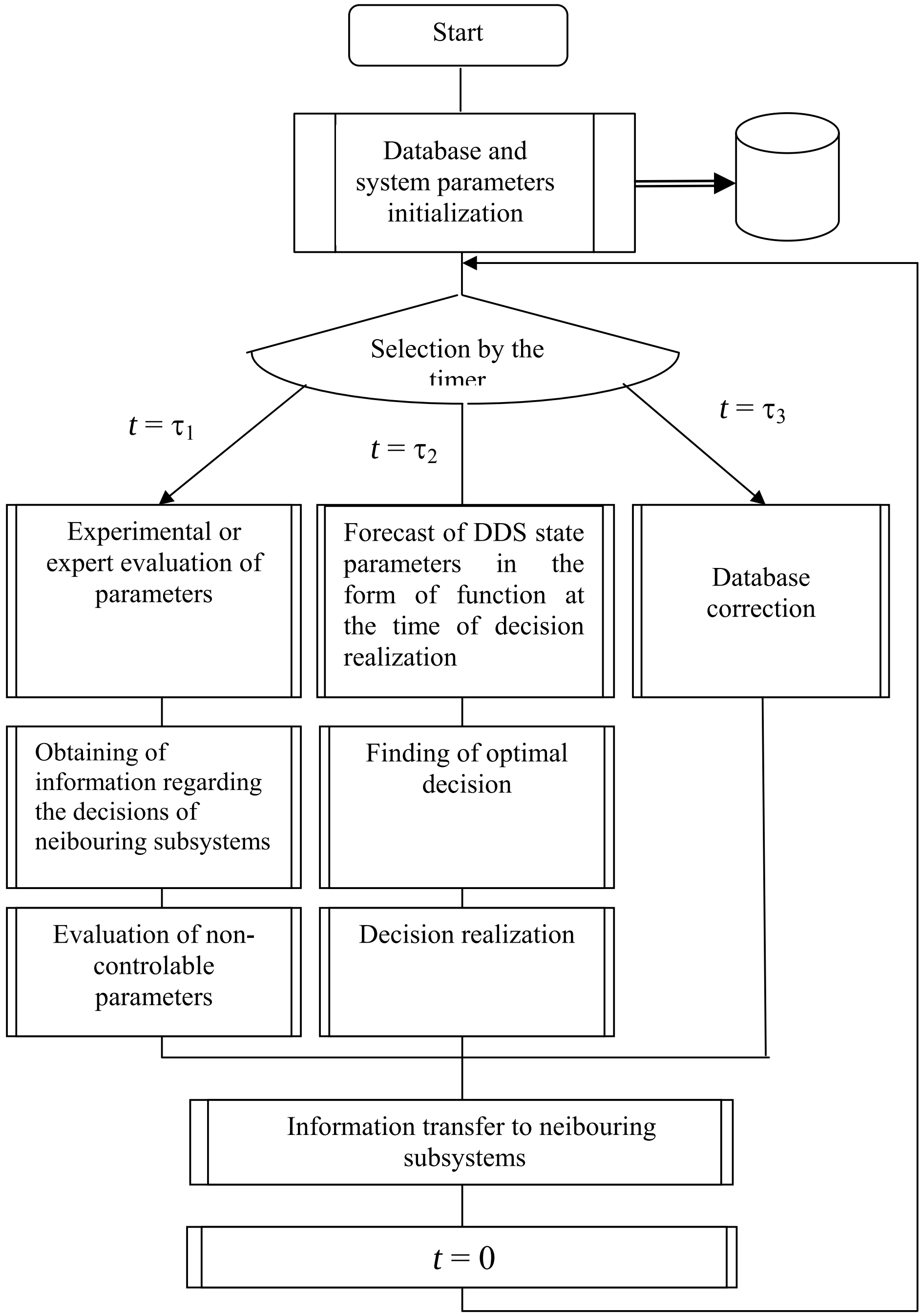

Fig. 3.Scheme of DM algorithm while process approach to DDS control

At first (initial) step of the algorithm defined the set of possible decisions D is defined, evaluation of the sensitivity of critical function F to DDS X parameters based on the model of influences distribution. List of parameters Y, which are essential to ensure the set quality solutions R is defined. Optimal frequency of the basic procedures of the algorithm is defined: control of DDS state, decisions making and realization, teaching of the system (correction databases and knowledge). Initial (design or expert) values of DDS parameters in the database and algorithm are set. At the second stage the number of fuzzy parameters, which are used for decision making are defined. This stage involves the construction of independence functions of fuzzy values based on expert data, as well as its conversion into function. After conversion of all fuzzy data, processing of stochastic information is carried out. At this stage the set of stochastic data affecting decision – making is set. The type of distribution law of each input and its conversion into function is further defined. After initial step cyclic process of DDS control starts, it consists of three streams of procedures:

- control of DDS state with the period of τ_1,
- decision making and realization with the period of τ_2
- system teaching (databases and knowledge correction) with the period of τ_3.

Study of information technology efficiency

To study the efficiency of the suggested IT simulation modeling was performed; in the process of modeling the traffic of transport vehicles in the transportation network of the city was modeled. Simulation algorithm consists of the following stages:

– Presentation of the transport network in the form of graph.
– Initialization of lights parameters.
– Generate initial point traffic.
– Generation of final points of the traffic.
– Determination of optimal traffic routes applying Deikstry algorithm.
– Modeling of transport vehicles motion and traffic lights operation.

Criteria selected amount of time modeling of traffic in the network.]

Using of IT was compared with models of decision making at intersections, built on the theory of statistic decisions (TSD), queueing theory (QT) and fuzzy logic (FL). The simulation results are presented in Table. 1.

Table 1

Results of simulation

Number of elements	Theory of statistic decisions, c.	Queueing theory, c.	Fuzzy logic, c.	Suggested IT, c.
1	65	78	67	70
5	352	383	371	365
10	683	674	681	652
15	1015	1047	1056	974
20	1428	1484	1490	1309
25	1907	1853	1945	1712
30	2615	2536	2581	2156

Graphic representation of the simulation results is shown in Fig. 4.

From research carried out, it follows that the results of the methods of decision-making for one element of the system do not differ greatly. However, the use of models and algorithms of IT allows to improve the optimality of decisions within a group of subsystems and system in general. The simulation results of the city transport network demonstrated the efficiency of the developed models and algorithms of decision- making information technology.

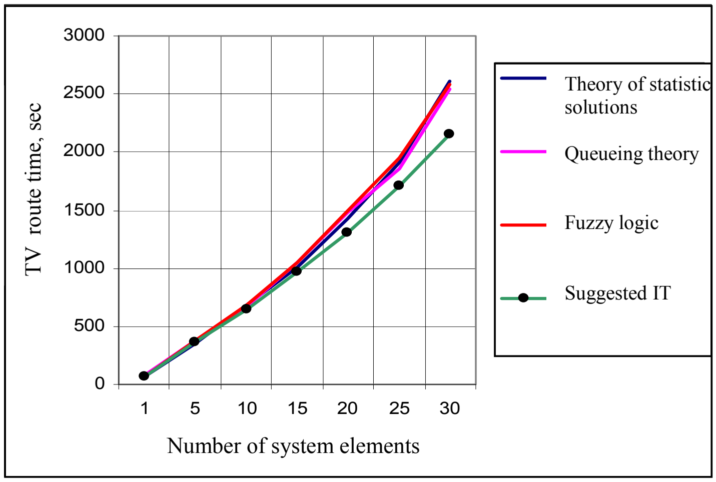

Fig. 4. Results of simulation

Conclusions

The suggested information technology allows to improve the quality of decision-making in DDS up to 15% due to taking into account elements interaction, system dynamics and uncertainty of stochastic and fuzzy character.

REFERENCES

1. Блюмин С. Л. Модели и методы принятия решений в условиях неопределенности / С. Л. Блюмин, И. А. Шуйкова. – Липецк: ЛЭГИ, 2001. – 138 с.

2. Месарович М. Теория иерархических многоуровневых систем / М. Месарович, Д. Мако, И. Такахара.– М.: Мир, 1973. – 332 с.

3. Kelly A. Decision Making Using Game Theory: An Introduction for Managers / A. Kelly. – Cambridge University Press, 2003. – 204.

4. Новиков Д.А. Сетевые структуры и организационные системы. М.: ИПУ РАН (научное издание), 2003. – 102 с.

5. Глонь О. В. Моделювання систем керування в умовах невизначеності. Монографія / О. В. Глонь, В. М. Дубовой. – Вінниця: УНІВЕРСУМ-Вінниця, 2004. – 170 с.

6. Ковалюк О. О. Моделі прийняття рішень в управлінні розподіленими динамічними системами. Монографія / В. М. Дубовой, О.О. Ковалюк– Вініиця: УНІВЕРСУМ – Вінниця, 2008. – 185 с.

Kovalyuk Oleg – Senior lecturer in computer systems.
Vinnitsa National Technical University.