UDC 621.391:681.5

MATHEMATICAL STATISTICS FUNCTIONALLY OBJECT MODEL FOR MONITORING AND CONTROL

Liubov N. Berkman, Larysa O. Komarova, Oksana G. Varfolomeeva, Iryna E. Pokhabova

State University of Telecommunications, Kyiv, Ukraine

The paper chain is seen as a complex system that is subject to management. The complexity of the process of monitoring and control is caused mainly complicated objects. To describe the operation of the facility built its functional and static mathematical model that completely describes the state of the object. The functional and statistical models to determine the probabilistic characteristics of information and communication network as object management. The model allows direct determination of the probability of the phase-out of the facility.

Statement of the problem

The object of monitoring and control can be any type of network infocommunication equipment as well as the entire network as a whole. The network is seen as a complex system that is subject to management. The complexity of the process of monitoring and control is caused mainly by complicated objects. To describe the operation of the facility it is advisable to build its mathematical model. Fullest state of the object describes a mathematical functional-static model – a system of equations or operators describing the dependence of output parameters object, system, or block of internal and external influences in the operation. On the basis of this model can be formulated the main problems solved by automatic monitoring and control, and to synthesize the optimal network management system, defining the extent of automation and efficiency.

In constructing mathematical models and statistical functionality necessary to consider that the network as a management object can consist of all kinds of classes and types. These systems can be autonomous and non-autonomous, closed and open, stationary and non-stationary, continuous and discrete. Therefore, the mathematical statistical model is functionally necessary to use very general mathematical tools, which when the appropriate changes can be extended to special cases. In addition, the construction of mathematical and statistical models of functional object must also be aware of the main criteria by which an optimization characteristics of the monitoring and control process.

These criteria primarily include:

- The time required to complete the process as a whole and its components;
- The probability of failure-free operation;
- The probability of a task different network elements belonging to the object, and the object as a whole;
- The probability of error;
- Delay transmission of information that controls;
- Availability factor;
- The percentage of packet loss;
- The accuracy of the various components of information and communication networks (deviation from normal parameters);
- The cost of consumed energy and other important indicators.

Consider the functional and statistical models to determine the probabilistic characteristics of information and communication network as object management. The model allows direct determination of the probability of the phase-out of the facility. It can be used in four base mathematical models: the method of ordinary differential equations, Monte Carlo, quasi-linear perturbation method and the method of canonical expansions.

The method of ordinary differential equations – a method of direct calculation of multidimensional probability density output parameters object using differential equations.

Monte Carlo method is repeated choosing of a random variable system parameters, followed by determination of the distribution of output parameters object.

Quasilinear perturbation method is to represent the output parameters in a Taylor series, followed by determination of the distribution of probability of the output parameters.

Consider the mathematical model of the object, based on the method of quasi-linear perturbation as the most simple, it offers important practical results, the method of integrating differential equations and the conditions of its use, as well as the Monte Carlo method.

The definition of a mathematical model of network element as an object monitoring and control

When the object of control refers to a set of complex and simple static and dynamic systems and components, as well as individual systems and components, whose characteristics are formed, controlled and customized for particular algorithms.

Under the parameters of multidimensional objects, systems and power mean value, functional relationships or operator is a measure of the quality of the object and describing the ability of an object to perform specified functions of governance.

In control and manage the operation of the object can be viewed as a multi-dimensional dynamic system, which includes automatic control systems (CS) together with managed objects (Fig. 3.1). In this system, along with natural and accidental managers actions or control signals affect different random noise in the form of external disturbances, which are usually the object, and internal operating in different functional blocks CS.

Perturbed state of the object in the control and management can be described by equations, mathematical functional model that is generally

$$\sum_{p=1}^{m} M_{lp}(t,\ \tau,\ \frac{d}{dt},\ Q)x_p = F_l(t,\ \tau,\ X,\ Z)$$

$$l = 1,\ 2,\ ...,\ m, \qquad (1)$$

where $X\{x_1,\ x_2,\ \ldots,\ x_m\}$ – vector of random functions of time, that characterize the output parameters of the object;

Z {ζ1, ζ2, ..., ζk} – vector of random functions of time, that characterize the external and internal disturbances and direct control actions (Fig. 3.1 acts that govern marked through F);

Fl – non-linear function of time;

$M_{lp}(t,\ \tau,\ \frac{d}{dt},\ Q)$ - Polynomial with respect to the differentiation operator $\frac{d}{dt}$ with variable time random vector of coefficients of $Q\{q1,\ q2,\ \ldots,\ q_m\}$;

t - current time value;

- Time to which the analyzed object.

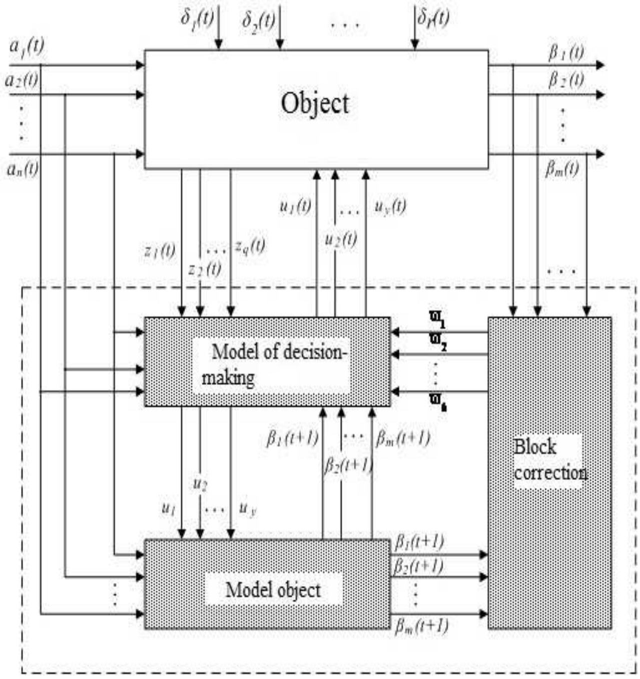

Fig. 1. Model Object Management

The system of equations (1) and, depending on the stage and the selected control algorithm can describe the dynamic state of the object, the control system of automated control. For example, the network FN, object control (CO) – a modem, software switch, router and so on. The process of site management is to ensure compliance with the parameters of a CO rule. Deviations from the normal parameters should not exceed the permissible value. In this case the object is random disturbances, as well as random and accidental actions. Chance of internal disturbance is caused, tolerances production; sudden deviation from the parameters of the settlement; gradual departure from the parameters of the settlement; sensitive equipment that is part of the government; various noises in force in other information channels.

Internal disturbances can be divided into direct and indirect. Direct internal disturbances are all perturbations acting on information channels (random ultimate precision and sensitivity of individual network elements, as well as all kinds of noise at the inputs of these elements). Indirect internal disturbances related disturbance affecting the output parameters when changing the network elements (accuracy settings of individual network elements, changes in operating conditions and operating mode CS).

Randomness is caused by external disturbances; accidental errors and functioning of control systems, random deviations of parameters of network elements from the settlement, making object errors, errors in the transmission and reception of information, errors CS, perturbations of the environment.

Randomness parameters of control signals or useful, may provide, in particular, the fact of accident occurrence of these signals. Thus, an action that controls, and disturbances acting on the object to be seen in statistical terms.

State of any dynamical system under the influence of control signals and disturbances, some output parameters are defined in some way connected with the actions of the system through an appropriate system of equations (3.1) vector operator dynamical system given by a set of mathematical $A(t,\ \tau,\ X,\ Z,\ Q)$ or operations, or a set of linear or nonlinear differential equations (1).

Due to the random nature of the various actions and output parameters perturbation, the facility will also be random functions of time.

Each group in nominal terms $t=\tau_0,\ x_{01},\ x_{0m},\ \zeta_{01},\ ...,\ \zeta_{0k}$, the nominal field G0 corresponds to their nominal solution of system (1):

$$x_{0i}=\varphi_{0i}(\tau_0,\ \tau,\ X_0,\ Z_o). \qquad (2)$$

Each group of real conditions $t=\tau_1,\ x_1,\ x_m,\ \zeta_1,\ ...,\ \zeta_k$ in real time region G1 corresponds to its real solution of the system (1):

$$x_i=\varphi_i(\tau_1,\ \tau,\ X,\ Z). \qquad (3)$$

The system of equations (3.1) in the number of nonlinear operators and outputs can be represented as m individual equations. For simplicity, assume that the number of output parameters equal to the number of operators, although there may be more. For ν-th parameter set of equations (3.1) becomes the equation:

$$M_{l\vartheta}(t,\ \tau,\ \frac{d}{dt},\ Q)x_\vartheta=F_l(t,\ \tau,\ x_\vartheta,\ Z). \qquad (4)$$

For a network element to this equation in the linearization may correspond to pulse $\omega(t,\ \tau,\ \mu,\ x_\nu,\ Z,\ Q)$, the transition $h(t,\ \tau,\ \mu,\ x_\nu,\ Z,\ Q)$, the transfer function of the system $W(t,\ \tau,\ p,\ x_\nu,\ Z,\ Q)$, amplitude $A(t,\ \tau,\ \omega,\ x_\nu,\ Z,\ Q)$ and phase $\varphi(t,\ \tau,\ \omega,\ x_\nu,\ Z,\ Q)$ frequency response of the system.

For objects that implement the functions of management route in the network packet, the number of output parameters is equal to or greater than the number of degrees of freedom, defined possible route packets in the network.

For example, the routing equation can be written as:

$$M_\gamma(t,\ \tau,\ \frac{d}{dt},\ Q_\gamma)x_\gamma=F_\gamma(t,\ \tau,\ \frac{d}{dt},\ Z_\gamma) \qquad (5)$$

$$M_\beta(t,\ \tau,\ \frac{d}{dt},\ Q_\beta)x_\beta=F_\beta(t,\ \tau,\ \frac{d}{dt},\ Z_\beta) \qquad (6)$$

$$M_\omega(t,\ \tau,\ \frac{d}{dt},\ Q_\omega)x_\omega=F_\omega(t,\ \tau,\ \frac{d}{dt},\ Z_\omega) \qquad (7)$$

where hγ – bias setting delay time packet transmission from the norm; hβ - bias setting packet loss probability from the norm; hω - rejection rate of information transfer from the normalized values and equations describing the rate of transmission of the network element:

$$M_\nu(t,\ \tau,\ \frac{d}{dt},\ Q_\nu)x_\nu=F_\nu(t,\ \tau,\ \frac{d}{dt},\ Z_\nu) \qquad (8)$$

$$M_\psi(t,\ \tau,\ \frac{d}{dt},\ Q_\psi)x_\psi=F_\psi(t,\ \tau,\ \frac{d}{dt},\ Z_\psi) \qquad (9)$$

$$M_\varphi(t,\ \tau,\ \frac{d}{dt},\ Q_\varphi)x_\varphi=F_\varphi(t,\ \tau,\ \frac{d}{dt},\ Z_\varphi) \qquad (10)$$

where ν – deflection frequency response from the norm; ψ - deviations Phase response from the norm; φ - jitter deviation from the norm.

In equations (5) - (10), the number of disturbances and control actions can be anything.

Adjustable parameters can be both dependent and independent hook. When the functioning of the network element (eg, a modem) is usually considered that the deviation from the normal parameters occur with relatively high frequency, but are small in value and virtually have little impact on the performance of the network. Therefore, in the preparation and analysis of equations describing the operation of the network element APFC channel can be neglected. In addition, the general rejection APFC channel compensated adaptive corrector or property of invariance OFDM signal. Thus, in some rare cases, the equation can be seen functioning of one of the controlled output parameters (for example, the probability of error) independent of other parameters (eg, APFC).

In control object control system certain parameters can be disconnected, and then depending on the selected criteria evaluation of systems analysis and synthesis of control systems and management can significantly be simplify.

Analysis of equation perturbed state of the object in the process of monitoring and control to determine the functional state of the object, the synthesis of control systems and evaluating its effectiveness. However, more complete characteristics of static and dynamic state of the object is probabilistic description by laws of probability distributions of parameter values and vectors operators.

References

1. V.K. Steklov, L.N. Berkman, O.G. Varfolomeeva Optimization of control systems with modern telecommunication networks // “Radiotekhnika” Ukrainian interdepartmental scientific and technical collection, Issue 125 – Kharkiv: KNURE. 2002. – 196 -202 pp.

2. V.K. Steklov, L.N. Berkman, O.G. Varfolomeeva Optimization of control systems with modern telecommunication networks // “Radiotekhnika” Ukrainian interdepartmental scientific and technical collection, Issue 125 – Kharkiv: KNURE. 2002. – 196 -202 pp.

3. L.N. Berkman Invariance of management systems of converged networks in emergencies / L.N. Berkman, L. A. Komarov, I. A. Boyko // Scientific Notes of Ukrainian Research Institute of Communications – 2014. – №1 (29). – 11-15 pp.

4. Technology of multifunction processing and information transfer in monitoring networks / [B.M. Shevchuk, V.K. Zadiraka, L.O. drive, S.V. Freier]. – K.: Naukova Dumka, 2010. – P. 370

5. T. Connolly Database. Design, implementation and support. Theory and practice / T. Connolly. – Moscow: Izdatelskiydom “Williams”, 2013 – P. 1440

Received in final form November 5, 2014