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OPTIMUM DIAGNOSING OF COMPUTER NETWORKS

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The basic calculation ratios for a scalar method of optimum diagnosing by sampling which allow analyzing, synthesis and optimization of scalar, vector and matrix systems of diagnosing are con National aviation university sidered. Diagnosing by sampling, optimum estimating of readouts, probabilities of mistakes, reliability of diagnosing

Introduction

Increase of efficiency of monitoring systems, diagnosing and forecasting of quality and reliability of computer networks - the important and actual economic problem. The big number of jobs of domestic and foreign authors [1, 2] is devoted to the decision of those or other tasks of this problem. Despite of it, the majority of laws and properties of the specified technologies is investigated insufficiently, on a number from them there are no techniques of an estimation of efficiency. It is caused not only obvious complexity of the problem, but also absence of uniform methods and design procedures of efficiency parameters of various technologies.

The purpose of job consists in ordering the basic settlement parities for a scalar method of optimum diagnosing by sampling [3], which forms a theoretical basis for construction of engineering methods and techniques of the analysis, synthesis and optimization of scalar, vector and matrix systems of computer networks diagnosing.

Statement of a problem

Known parities for systems efficiency parameters of the unitary control of the diagnostic parameters determining a technical condition of a computer network are assumed. In a role of diagnostic parameters usually consider throughput of the chosen route in networks, time of a delay of packages at data transmission on the certain route, operating ratio of throughput of the multichannel communication line and others. It is necessary to generalize these parities on cases of a choice of a field of admissions on value of probability of non-failure operation and use of optimum estimating of readouts.

The decision of a problem

In the beginning we shall remind essence of a classical method of optimum diagnosing by sampling [6]. Stimulating signal $S(t)$ from the device of stimulation acts on object of diagnosing, target diagnostic signal $X(t)$ is measured by means of diagnosing at presence of an interference $\xi(t)$, which acting from a source. Measured value $Y(t)$ (readout) of a signal acts on the device optimum estimating, which with the help of optimum parameters γ_{opt} and Z_{opt}, acting from the first memory, develops an optimum estimation $X^*_{opt}(t)$ diagnostic parameter $X(t)$. By this estimation, size of a field of the admission δ, ΔH and σ_ξ, acting of the second memory, deciding device makes a decision R_1 about that OD is in i-th a condition. This decision is displayed by the device of indication and registered by the device of documenting.

Readout value Y_i at the moment of diagnosing ti receive as

$$Y(t_i)=(t_i)+\xi(t_i)=Y_i, \qquad (1)$$

whether define value has got $Y(t_i)$ in a field of the admission [a, b], if $Y_i \in \{a,b\}$, make a decision, that the object is in a serviceable condition.

Let's designate through $f_1(x)$, $f_2(\xi)$, accordingly, distribution densities of a diagnostic signal and an interference at the moment t_i of sampling. Probability P of the staying of a diagnostic signal in a field of the admission in this method gets out equal probability $P(t_i)=P_i$ non-failure operation of object at the sampling moment t_i.

$$P(t_i)=\int_a^b f_i(x,t_i)dx=P_i\,. \qquad (2)$$

Parameters of efficiency of a scalar method of optimum diagnosing by sampling are defined by known parities in view of features of a choice of a field of the admission and optimum estimating values of diagnostic parameter on readout.

Full probability of the first kind mistake (a serviceable object to recognize faulty)

$$\alpha=\int_a^b f_1(x)\left[\int_{-\infty}^{a-x} f_2(\xi)d\xi\right]dx+ \int_a^b f_1(x)\left[\int_{b-x}^{\infty} f_2(\xi)d\xi\right]dx. \qquad (3)$$

Full probability of the second kind mistake (a faulty object to recognize serviceable)

$$\beta=\int_{-\infty}^{a} f_1(x)\left[\int_{a-x}^{b-x} f_2(\xi)d\xi\right]dx+ \int_b^{-\infty} f_1(x)\left[\int_{a-x}^{b-x} f_2(\xi)d\xi\right]dx. \qquad (4)$$

Full probability of a diagnosing mistake

$$Q=\alpha+\beta\,. \qquad (5)$$

Full probability of correct diagnosing

$$D=1-Q=1-\alpha-\beta\,. \qquad (6)$$

Conditional probability of the first kind mistake

$$P_F=P(F/S)=\alpha/P\,. \qquad (7)$$

Conditional probability of the second kind mistake

$$P_S=P(S/F)=\beta/(1-P)\,. \qquad (8)$$

Probability characteristics of diagnosing are convenient for calculating, carrying out necessary linear transformations and using normalized variables [2]

$$Z_1=\frac{X(t)-m_x}{\sigma_x};\, Z_2=\frac{\xi(t)-m_\xi}{\sigma_\xi}, \qquad (9)$$

which for any moment of time have a zero mathematical expectation (population mean) and the dispersion is equal to unit. Having executed replacement of variables, we shall receive

$$P=\int_{-\eta}^{\eta}\sigma_x f_1(Z_1)dZ_1, \qquad (10)$$

$$\alpha=\int_{-\eta}^{\eta}\sigma_x f_1(Z_1)\left[\int_{-\infty}^{-\frac{\sigma_x}{\sigma_\xi}(\eta+Z_1)}\sigma_\xi f_2(Z_2)dZ_2\right]dZ_1+ \int_{-\eta}^{\eta}\sigma_x f_1(Z_1)\left[\int_{\frac{\sigma_x}{\sigma_\xi}(\eta+Z_1)}^{\infty}\sigma_\xi f_2(Z_2)dZ_2\right]dZ_1, \qquad (11)$$

$$\beta=\int_{-\infty}^{\eta}\sigma_x f_1(Z_1)\left[\int_{-\frac{\sigma_x}{\sigma_\xi}(\eta+Z_1)}^{\frac{\sigma_x}{\sigma_\xi}(\eta-Z_1)}\sigma_\xi f_2(Z_2)dZ_2\right]dZ_1+ \int_{\eta}^{\infty}\sigma_x f_1(Z_1)\left[\int_{-\frac{\sigma_x}{\sigma_\xi}(\eta+Z_1)}^{\frac{\sigma_x}{\sigma_\xi}(\eta-Z_1)}\sigma_\xi f_2(Z_2)dZ_2\right]dZ_l \qquad (12)$$

where the absolute and normalized admissions define parities

$$\delta=\frac{b-a}{2};\; \eta=\frac{b-a}{2\sigma_x}=\frac{\delta}{\sigma_x}. \qquad (13)$$

In unitary diagnosing by sampling the normalized admission, the absolute admission, average quadratic value of interference σ_ξ and the signal/noise attitude $\Delta H=P_x/P_\xi$ are connected by parities:

$$\eta=\frac{\delta}{\delta_\xi\sqrt{\Delta H}}=\frac{\delta}{\delta_\xi\sqrt{P_x/P_\xi}}= =\frac{\delta}{\delta_\xi\sqrt{e^{\Delta D}}}=\frac{\delta/\sigma_\xi}{\sigma_x/\delta_\xi}. \qquad (14)$$

From these parities it follows what to operate diagnosing with unitary by sampling at fixed σ_ξ it is possible three ways: changing, ΔD or simultaneously δ and ΔD at the fixed value σ_ξ Efficiency of diagnosing is defined with parities:

$$\eta\sqrt{e^{\Delta D}}=\frac{\delta}{\sigma_\xi};\; \sigma_\xi\eta=\delta\big/\sqrt{e^{\Delta D}}\,. \qquad (15)$$

Parities (15) evidently show, how lack of a dynamic range "exchanges" for width of a field of the admission: at the big dynamic range of a signal it is possible without fear to narrow a field of the admission. The condition (14) is a condition of equivalence on probability of a mistake of three ways of management in volume of the diagnostic information in unitary diagnosing by sampling.

Efficiency of unitary diagnosing by sampling can be connected with all parameters of a signal volume if to impose an additional condition, that duration readout is multiple to an interval of digitization of a diagnostic signal on Kotelnicov's theorem, then capacity of a diagnostic signal in sampling time

$$P_S = \frac{\nu k}{\Delta T} \int_{-\Delta T/2\nu k}^{\Delta T/2\nu k} X^2(t)dt = \frac{E(\Delta T, \nu, k)}{\Delta T}, \quad (16)$$

Example 1

We shall consider, how efficiency of unitary diagnosing by sampling a signal, which volume is equal unit, changes at various width of a field of the admission. For definiteness we shall choose expansion of the normalized field of the admission from $\eta_1 = 2{,}5$ up to $\eta_2 = 3$, that is equivalent to increase of a signal volume from 1 nit up to 1,2 nit.

At $\eta_1 = 2{,}5$, using parities (10) - (15), (5) - (8), we shall receive

$P_1 = 0{,}8758$; $\alpha_1 = 0{,}021$; $\beta_1 = 0{,}009$;
$Q_1 = 0{,}03$; $D_1 = 0{,}97$; $P_{F_1} = 0{,}024$;
$P_{S_1} = 0{,}072$.

At $\eta_2 = 3$, we shall receive

$P_2 = 0{,}973$; $\alpha_2 = 0{,}008$; $\beta_2 = 0{,}004$;
$Q_2 = 0{,}012$; $D_2 = 0{,}988$;
$P_{F_2} = 0{,}0082$; $P_{S_2} = 0{,}148$.

Thus, increase of a field of the admission δ on $0{,}5\sigma_x$ it is equivalent to increase of a signal volume on 0,2 nit, that is equivalent to increase of the attitude signal/noise in 1,2 times. Thus, the probability α decreases in 2,62 times, β - in 2,25 times, Q - in 2,5 times, P_F - in 2,9 times, P_S grows in 2,04 times. Parameter D of diagnosing reliability grows from 0,97 up to 0,988, that is approximately by 1,86 %. From here follows, that parameters of diagnosing efficiency it is essential and nonlinearly depend on volume of a diagnosed signal, the attitude signal/noise and fields of the admission.

Utility of parities (9) - (14) that they quantitatively allow to estimate influence of all parameters of a signal volume and other parameters determining a mode of diagnosing, on parameters of diagnosing efficiency. It enables to make the proved optimum administrative decisions.

The volume of the diagnostic information in a scalar method of optimum diagnosing by sampling grows at the expense of performance of optimum processing the measured values (readouts). Optimum processing results in increase the signal/noise attitude on an input of deciding device of diagnosing system, and it, as shown above, is equivalent to increase of a signal volume.

Optimum estimation X^* true value of diagnostic parameter X it is searched as linear function Y

$$X^* = \gamma Y + (1-\gamma)Z, \quad (17)$$

where γ and Z are parameters of an estimation $X^*(\gamma, Z, Y)$, which are necessary for choosing optimum by the certain criterion. In a scalar method of optimum diagnosing by sampling it is used average guadratic of a kind

$$\left.\begin{aligned} \varepsilon^2 &= M\left[(X - X^*)^2\right] = \\ &= M\left\{[X - \gamma Y - (1-\gamma)Z]^2\right\} \end{aligned}\right\} \quad (18)$$

After definition of a population mean of the right part, differentiation ε^2 on α and Z, equating of the received derivatives to zero, the joint decision of the received two optimization equations, for optimum estimations of parameters we shall receive parities

$$Z_{opt} = m_x; \; \gamma_{opt} = \frac{\sigma_x^2}{\sigma_x^2 + \sigma_\xi^2} = \frac{\Delta H}{\Delta H + 1}. \quad (19)$$

Optimum estimation X^*_{opt} diagnostic signal X on readout Y it is equal

$$X^*_{opt} = \frac{\Delta H}{\Delta H + 1} Y + \frac{1}{\Delta H + 1} m_x. \quad (20)$$

Population mean and dispersion of an estimation X^*_{opt}

$$M\left[X^*_{opt}\right] = m_x; \; D\left[X^*_{opt}\right] = \sigma_x^2\left(\frac{\Delta H}{\Delta H + 1}\right). \quad (21)$$

It designates, that for reception on an input of deciding device of the signal/noise attitude equal ΔH, on an input of the optimum estimating device the signal/noise attitude can be in $1/\gamma_{opt}$ time is less. Hence, optimum estimating is equivalent to increase of the attitude signal/noise in $1/\gamma_{opt}$ time and to increase of a signal volume at size

$$\Delta V = \Delta T \Delta F[\ln(\Delta H + 1) - \ln(\Delta H)]. \quad (22)$$

Example 2

We shall estimate that optimum processing of the readouts gives a diagnostic unit signal. For this case optimum estimating of diagnostic signal parameters is equivalent to increase of its volume at size

$$\Delta V_1 = \ln(e+1) - \ln e = \ln\frac{e+1}{e} = 0{,}313 nit. \qquad (23)$$

As shown above, at other equal, it will result in essential increase of diagnosing efficiency as the signal/noise attitude on a voltage to increase in 1,17 times: from 1,648 up to 1,928.

This example evidently illustrates that application of various ways of optimal processing of readouts allows receiving various efficiency of diagnosing. Therefore in a considered direction problems of preliminary optimal processing of the measured values of diagnostic signals are actually.

As the increase of volume of the diagnostic information by optimal processing the measured values raises the signal/noise attitude on an input of deciding device, this operation allows at other equal to narrow a field of the admission and, hence, is more exact to estimate a condition of object. In other words, the optimal processing raises not only reliability of diagnosing, but also accuracy.

Conclusions

1. Parities (9) - (16), (17), (19) - (23) for calculation of efficiency parameters of a scalar method of optimal diagnosing by sampling are offered to use as the general theoretical basis of parameters calculation for efficiency of scalar, vector and matrix systems of optimal diagnosing by sampling of diagnostic signals.

2. The specified parities establish interrelations between all basic characteristics of offered technology of diagnosing by sampling with optimal estimating values of readouts. It allows estimating their joint influence on the diagnostic efficiency of systems constructed on the basis of this technology. It is necessary especially to note an opportunity of definition of the volume influence of the information received at unitary diagnosing on probability of mistakes, reliability and accuracy of diagnosing.

3. Use of the formula of full probability and formula Byes allows to use results of diagnosing for posteriori estimating of the reliability and, simultaneously to rise of diagnosing efficiency on specified to posteriori estimations of reliability of object.

Literature

1. *Игнатов В.А., Паук С.М., Конахович Г.Ф.* и др. Диагностические комплексы систем автоматического самолетовождения. Под ред. В.А.Игнатова. – М.: Транспорт. 1975. – 272 с.

2. *Игнатов В.А., Таджи Тайсир, Уланский В.В.* Оптимальные задачи обслуживания авиационных систем на основе контроля работоспособности. - Прогрессивные методы эксплуатации радиоэлектронного оборудования аэропортов и воздушных трасс гражданской авиации. – К.: КИИГА, 1982. – С. 9 – 18.

3. *Игнатов В.А., Стоянов Б.Н.* Метод избыточного диагностирования авиационных систем. - Технологические процессы при эксплуатации радиоэлектронного оборудования гражданской авиации. – К.: КИИГА, 1985. – С. 7 – 17.

4. *Боголюбов Н.В., Игнатов В.А.* Управление информационной избыточностью систем диагностирования и контроля. - Контроль и управление техническим состоянием авиационного и радиоэлектронного оборудования воздушных судов гражданской авиации. – К.: КИИГА, 1986. – С. 3 –11.

5. *Игнатов В.А., Мачалин И.А.* Оптимальное управление диагностированием изделий авиационной техники. – Авиационная и космическая техника. – Харьков: ХАИ, 2006, №6. – С. 5 – 18.

6. *Игнатов* В.А. Теория информации и передачи сигналов. - М.: Сов. радио, 1980. – 280 с.

7. *Игнатов В.А., Тараненко А.Г.* Авиационные системы диагностирования. – К: КИИГА, 1990. – 200 с.

8. *Игнатов В.А., Мачалин И.А.* Расчетные соотношения метода оптимального диагностирования стробированием. – Авиационная и космическая техника. – Харьков: ХАИ, 2006, №7. – С. 7 – 13.