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Model Of The Network Method Of Optimization Of The Routers For Exchange Of The Information Between Elements Of Automated Control Systems

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Abstract
This paper proposes a method of increasing the efficiency of the automated control systems. A model of the implementation of network optimization method routes the exchange of information between elements of the automated control systems.
For increase of overall performance of an automated control system of rigidly regulated mode of real time it is necessary to reduce time for transfer and reception of information and to increase the speed of exchange of information between its elements. To increase the speed of exchange of information between elements of automated control systems, it is necessary to optimize routes of its delivery.

Keywords: network method, schedule, efficiency, telecommunication network of data exchange, automated control system.

INTRODUCTION

Work purpose: to develop model of optimization of routes of exchange of information between elements of automated control systems that will allow to reduce terms of passing of information, so and will increase efficiency of automated control systems.
In this article it is offered to optimize routes of exchange of information by a network method [1,12] which allows to define the optimum organization of information transfer in automated control systems by minimization of temporary characteristics and the cost of a telecommunication network of data exchange for the purpose of receiving the maximum effect. At research of a telecommunication network of data exchange by a network method it is presented in the form of a network of events and operations. Such network can be model of process of information transfer. This model demonstrates interrelation of all elements of process of transfer.
The graphic representation of a network is called as the network schedule. The network schedule represents the image in the corresponding scale of events and operations. Events are designated by the corresponding badges (circles), operations – vectors which length reflects branch weight, and the direction – sequence of performance of events. This schedule is used when processing a network. On the network schedule to all events, except initial, operations have to precede. Besides, contours of works and events are eliminated (loops on the ways of information transfer). Operations of the network schedule characterize duration of these operations in time and if necessary by economic costs of performance of these operations.

Formulation of the problem

When processing the network schedule determine duration of operations on information transfer and quantitative parameters of a network. As a result of processing the structure of a critical path is established, calculated the early terms of a fulfillment of events, late admissible terms of a fulfillment of events and reserves of time of events. At determination of duration of operations the determined and probabilistic methods are used.At the first method for each operation one strictly certain value of duration is specified, at the second it is supposed that duration of operations is a random variable. In this case for an assessment of duration of operation can be used: the most probabilistic time of operation (realistic assessment) $t_{n.v}$, minimum time (optimistic assessment) $t_{min}$and maximum time (pessimistic assessment) t_{max}.For operations on the network schedule the following ratio has to be carried out:

$$t_{min} \leq t_{n.v.} \geq t_{max} \qquad (1).$$

Besides, at a probabilistic method for each operation i, jthe average duration of this operation $\overline{t_{i,j}}$ and its dispersion are defined $\sigma^2_{t_{i,j}}$.In [1,2,3] average period of operation and its dispersion are estimated provided that the random variable of period of operation is subordinated to the law - distributions. In this case communication between t_{min}, t_{max}, $t_{n.v}$, $\overline{t_{i,j}}$,$\sigma^2_{t_{i,j}}$is defined by expressions

$$\overline{t_{i,j}} = \frac{t_{\min} + 4t_{n.v} + t_{\max}}{6} \qquad (2);$$

$$\sigma^2_{t_{i,j}} = \left(\frac{t_{\max} - t_{\min}}{6}\right)^2 \qquad (3).$$

After calculating the values $\overline{t_{i,j}}$, $\sigma^2_{t_{i,j}}$ identified and refined assessment of operations with great uncertainty $(t_{\max} >> t_{\min})$. Excessively uncertainestimates of terms of information transfer in a telecommunication network of data exchange are very undesirable as mistakes in network processing in process of movement from information source to the recipient collect. It can prevent finding of the optimum

decision. In case of receiving similar estimates with big uncertainty processing of the corresponding site of the network schedule is made by method of the logical analysis [4,11].
Thus, the statement of the problem is reducedto finding of such most probabilistic time of the operation $t_{n.v}$, which would meet a condition $t_{\min} \le t_{n,v} \le t_{\max}$.

The method of solution
In the method of logical analysis used the ratio

$$\varphi = \frac{\sigma_{t_{i,j}}}{\overline{t_{i,j}}} \quad (4).$$

The calculated values of duration of operations $\overline{t_{i,j}}$ and its dispersion $\sigma^2_{t_{i,j}}$ are caused on the network schedule. Badges of events on the network schedule share on four equal sectors. In the top sector of each badge serial number No. of the corresponding event registers. Other sectors of each badge are used for record of the calculated quantitative parameters of events.Nearlyeach vector of operation the calculated values of the expected duration of operation$t_{i,j}$and its dispersion $\sigma^2_{t_{i,j}}$ (with a probabilistic assessment).Quantitative parameters of events of a network are defined in the following sequence: for each event ofi calculated the earliest expected term of a fulfillment of an event t_{ri} and its dispersion $\sigma^2_{t_{ri}}$, the latest admissible term of a fulfillment of an event t_{pi} and its dispersion $\sigma^2_{t_{pi}}$, a reserve of time of an event t_{res_i} and its dispersion $\sigma^2_{t_{res_i}}$ .Calculation of sizes t_{ri} is made, since an initial event by transition from the previous events to the subsequent on the general formula

$$t_{ri} = \max\left[t_{ri} + \overline{t_{i,j}}\right] \quad (5),$$

wherej – numbers of the events which are directly preceding the eventi. Values t_{ri} are brought on graphics in the left sector of badges of the corresponding events.If to an event converges some operations, operation by which value is determined t_{ri}, usually allocate with any badge, for example, an asterisk, about its edge. For an initial event accept $t_r = 0;\ \sigma^2_{t_r} = 0$ .For an eventi when it is preceded by one operation, the early possible term of a fulfillment of an event

$$t_{ri} = t_{ri-1} + \overline{t_{i-1,i}} \quad (6).$$

At probabilistic approach [5,10] also dispersion of size is defined

$$\sigma^2_{t_{ri}} = \sigma^2_{t_{ri-1}} + \sigma^2_{t_{i-1,i}} \quad (7)$$

For a case when to an event of i is preceded by nof operations, the early possible term of a fulfillment of an event,

$$t_{ri} = \max(t_{r1}, t_{r2}, \ldots, t_{rn}),\ \text{i}=1,2,\ldots,\text{n}. \quad (8).$$

At probabilistic approach also dispersion of size t_{ri} is defined:

$$\sigma^2_{t_{ri}} = \sigma^2_{i_{ri}} + \sigma^2_{t_{k,i}} \quad (9),$$

where k – number of the event which is directly preceding an event (i) and i separated from an event operation of the greatest duration.Calculation of size t_{pi} is made, since a final event by transition from the subsequent events to the previous. For a final event size t_p is equated to the set control completion date of information transfer in a network t_k or size t_r if this term isn't set.Calculation is made on the general formula

$$t_{pi} = \min\left[t_{pj} - t_{i,j}\right] \quad (10)$$

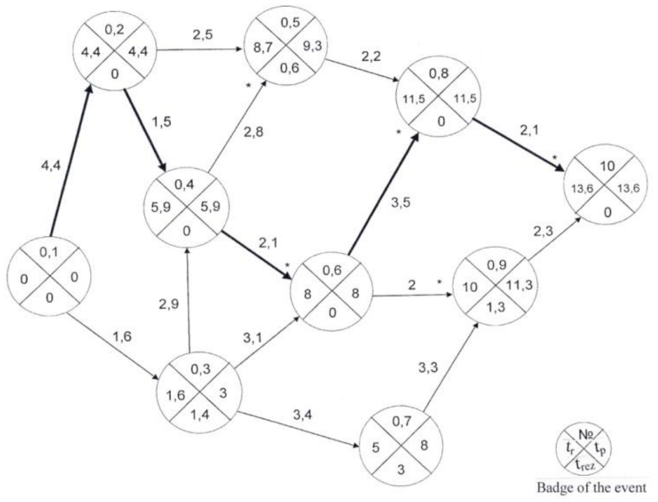
,
where by j – number of the event which is directly following i event. Values t_{pi} are brought on the schedule in the right sector of badges of the corresponding events.For a case when i event is followed directly by k of operations, the late admissible term of a fulfillment of an event

$$t_{pi} = \min\left(t_{p1}, t_{p2}, \ldots, t_{pk}\right),\ i = 1,2,\ldots,k,\ldots \quad (11)$$

where - $t_{p1}, t_{p2}, \ldots, t_{pk}$ the values of size t_p received taking into account each of k of the operations which are directly following i event.At probabilistic approach also dispersion of size t_{pi} is defined: $\sigma^2_{t_{pi}} = \sigma^2_{t_{pi}} + \sigma^2_{t_{i,j}}$ where j – number of the event which is directly following an event of i and lying on the way which gives the minimum value t_{pi}. Reserves of time of events

$$t_{res} = t_{pi} - t_{ri} \quad (12)$$

.
Values t_{resi} are brought on graphics in the lower sector of badges of the corresponding events. The structure of a critical way is defined by viewing of the network schedule, since a final event and continuing it from the subsequent events to previous.The operations which don't have reserves of time and limiting them events are a part of a critical way. In a network there can be some critical ways. Other ways of a network are called not intense. Not intense ways have some reserve of time. The simplest processing of the network schedule on it comes to an end. We will consider processing of the network schedule on the example of a telecommunication network of data exchange which count is given in figure 1.



The Rice 1. Processed network graph oriented telecommunication network of the data exchange (the fat line is shown critical way of the issue to information)

This network is focused in the direction of a hub 10. In drawing the processed network schedule of this focused telecommunication network of data exchange is shown. Control term t_k is accepted equal to the early possible term of a fulfillment of a final event. The critical way of information transfer passes through events 01-02-04-06-08-10. The total duration of operations of a critical way is equal 13,6. At probabilistic approach in addition to the analysis of the network schedule define also probability of that information transfer in a telecommunication network of data exchange will be finished to the set control term t_k .This usually provides an assessment of scattering on the assumption that the time of the final event has a normal distribution.It is fair if durations of the operations making a critical way are mutually independent and the critical way consists of rather large number of operations. So-called "side" influences of the operations which aren't entering a critical way thus aren't considered. For this case average value of the moment of approach of a final event

$$\overline{t_{r.k.s.}} = t_{r.n} + \sum_{kr.p} \overline{t_{i,j}} \quad (13)$$

,

where $t_{r.n}$ - moment of the beginning of transfer or present situation of time; $\sum_{kr.p} \overline{t_{i,j}}$ - total duration of works of a critical way.

Dispersion of time of approach of a final event

$$\sigma^2_{t_{r.k.s}} = \sum_{kr.p} \sigma_i^2 \quad (14)$$

.

Where σ_i^2 – dispersion of the moment of approach of an event of i entering a critical way. At "side" influence some operations which are becoming isolated on this or that event of a critical way can end after the corresponding operation of a critical way and, thus, the moment of a fulfillment of this event on the critical way will appear later. "Side" influences decrease at increase of reserves of time of intense ways and reduction of dispersion of duration of operations. In practice determination of size $t_{r.k.s}$ on operations of a critical way is quite satisfactory on accuracy. The probability of that information transfer in a network will be finished to the set control term

$$P_{z.k} = \Phi\left[\frac{t_k - \overline{t_{r.k.s}}}{\sigma_{\overline{t_{r.k.s}}}}\right] \quad (15)$$

,

Where $\Phi\,[x]$ - the tabulated function of normal distribution

$$\Phi(t) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{t} e^{-\frac{x^2}{2}} dx . \quad (16)$$

Conclusion

Thus, at the organization of information transfer in automated control systems the analysis of a critical way allows to reveal branches of a telecommunication network of data exchange on which information transfer in the established control terms depends, and to concentrate attention on the "narrowest" places. The critical way can be reduced by use of means of communication with a bigger capacity or reduction of volumes of the transmitted data. As a result of it new parameters of a network have to be received.Consecutive clarifying of the network schedule achieve performance of an inequality $\overline{t_{r.k.s}} \le t_k$. If duration of a critical way nevertheless doesn't provide performance of control term of information transfer t_k, it is necessary to change control term. In summary, at clarifying of a network, check, whether the critical way changed and whether the inequality $t_r \le t_p$ for the events depending on operations where at clarifying of a network other means of communication were put is broken or volumes of the transmitted data are reduced. Determination of key parameters of a network by the considered technique is the confidant. However the received accuracy (15-20%) has enough for engineering calculations [7,8,9].

Using the offered optimization model, in practice process is automated by means of appropriate programs for work of routers of a network.

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