

Development, research of a model and an algorithm for organizing data transfer in a monitoring device

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Abstract. The article examines the use of the graph theory method, in particular, the Petri net graph, for the development of microprocessor devices for remote continuous monitoring of the state of railway automation control equipment using Internet of Things technologies. Based on it, the model of the behavior of a set of modules that determines the state of automatic blocking signal point devices was studied.

1 Introduction

Ensuring the safe management of the transport process is mainly assigned to the devices of railway automation and telemechanics. The safety requirements for these systems are currently implemented by using relays of the first reliability class in devices and units directly related to the movement of trains. Railway automation and telemechanics devices that directly ensure the safe movement of trains are located in relay cabinets in the immediate vicinity of traffic lights, if the sections are equipped with an automatic blocking system. The reliable operation of these devices directly affects the successful implementation of the approved train schedule. And it goes without saying that their failure leads to the failure of the schedule, which directly leads to economic losses. An analysis of the operating conditions of outdoor devices of the auto-blocking system indicates many factors that contribute to a decrease in their performance, namely, a rather high temperature in summer in relay cabinets (up to +60) and low temperature in winter (up to -40). Constant vibration of the soil caused by the passage of heavy freight trains. All this leads to the need for constant monitoring of the state of the devices of the signal point of automatic blocking. Continuous monitoring of the technical condition by the maintenance personnel is impossible due to the territorial distance of the signal points from the station. In addition, most of the main equipment that ensures the safety of train traffic is devices and tools whose service life has exceeded 30 years, this explains short-term damage caused by the state of morally and technically obsolete equipment. In this regard, the creation and implementation of new railway automation systems using microelectronic technologies is an urgent innovative scientific task. The use of the achievements of modern microelectronic technologies allows for more efficient and safe control of the transport process [1].

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Reliable operation of such systems is possible if there is sufficient, reliable and timely information about the state of railway automation and remote control devices [2]. In this situation, issues related to the introduction of computer technologies, microcontrollers in devices and systems of railway automation and telemechanics, instead of traditional relay devices and systems, become of great importance [3, 4].

One of the ways to increase the reliability of technical means that ensure optimal control of train traffic is the introduction of devices that do not contain mechanical switching, which are directly involved in laying and opening train routes. The creation of an innovative project lies in the fact that in the existing system of auto-blocking by means of microelectronic technologies it is possible to provide continuous monitoring of the state of the signal point devices and its timely delivery to maintenance personnel without the use of a physical communication line [5].

2 Methods

To achieve the goal of developing microprocessor devices for continuous monitoring of the state of railway automation and remote control equipment using the "Internet of things" technologies, the graph theory method, in particular, the labeled Petri net graph, was used. On its basis, a model for the behavior of a complex of modules that determine the state of devices of the signal point of auto-lock was investigated [3-6].

3 Results and Discussion

In accordance with the task of the study, it is necessary to develop "n" - the number of modules whose task is to measure, process and form a data packet for transmitting information to the station. At the same time, it should be borne in mind that a specialized module is responsible for the organization of the communication channel, the functional responsibilities of which are reduced to sequential access to the channel of a total of "n" - the number of specialized modules. To research and develop an algorithm for the operation of the information transmission module, a model based on a labeled graph of Petri nets has been developed, shown in Fig. 1 [6, 7, 2], where:

P_S - position reflecting the state of the object during the transmission of information;

\overline{P}_S - position reflecting the inverse state of the object P_S , i.e. lack of information transfer;

P_1 - position reflecting the state of the object at the end of the procedure for determining the actual voltage on the windings of the impulse relay;

P_2 - position reflecting the state of the object at the end of the procedure for determining the actual output voltage of the track circuit;

P_n - position reflecting the state of the n-th object.

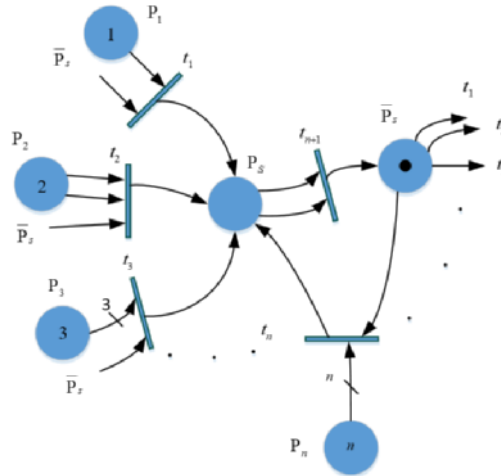


Fig. 1. Petri net graph of the initial state of the monitoring device.

At the same time, chips are placed in each position $P_1, P_2, P_3 \dots P_n$ after the measurement procedure is completed and the module is ready to transmit information [8-10]. The number of chips placed is determined by the position number, for example, at the end of the procedure for determining the actual voltage on the windings of the pulse relay, one chip is placed in position P_1 . Consider the operation of the model, in the initial state, when all n-modules have not completed the procedure for determining the parameters of the objects assigned to them, there are no tokens in all positions, with the exception of the \bar{P}_s position, which has a token, which corresponds to a break in information transfer (Fig. 1).

For the Petri net graph Fig.1, extended input and output functions are given (1).

$$\begin{aligned}
 I(P_s) &= \{t_1, t_2, t_3 \dots t_n\}; & O(P_s) &= \{t_{n+1}\}; \\
 I(\bar{P}_s) &= \{t_{n+1}\}; & O(\bar{P}_s) &= \{t_1, t_2, t_3 \dots t_n\}; \\
 & & O(P_2) &= \{t_2\}; \\
 & & O(P_3) &= \{t_3\}; \\
 & \dots \dots & & \\
 & & O(P_n) &= \{t_n\}; & (1) \\
 I(t_1) &= \{P_1, \bar{P}_s\}; & O(t_1) &= \{P_s\}; \\
 I(t_2) &= \{P_2, \bar{P}_s\}; & O(t_2) &= \{P_s\}; \\
 I(t_3) &= \{P_3, \bar{P}_s\}; & O(t_3) &= \{P_s\}; \\
 & \dots \dots & & \\
 I(t_n) &= \{P_n, \bar{P}_s\}. & O(t_n) &= \{P_s\}. \\
 I(t_{n+1}) &= \{P_n\}. & O(t_{n+1}) &= \{\bar{P}_s\}.
 \end{aligned}$$

At the moment when the module for determining the actual voltage on the windings of the impulse relay has completed its work and is ready to transmit the received information to the station, then one chip is placed in position P_1 (Fig. 2).

In accordance with the extended input (I) and output (O) functions of the graph, which are given in (1), the output function $O(P_1) = \{t_1\}$ and the transition input function $I(t_1) = \{P_1, \bar{P}_s\}$, it is clear that all the input positions of the transition t_1 have chips and therefore this the transition is ready to start, which will lead to the redistribution of chips according to the output function $O(t_1) = \{P_s\}$ and the assignment of the chip to the position

P_s and the removal of the chip from the position \bar{P}_s Fig. 3, which in turn confirms the possibility of capturing the information transmission channel by the module for determining the actual voltage on the windings of the impulse relay. Upon completion of the procedure for transferring information to the P_s position, another Fig. 4 is added [8-10].

As a result, conditions are created for triggering the transition t_n according to its input function $I(t_{n+1}) = \{P_n\}$ and moving the token to position \bar{P}_s , in accordance with the output function $O(t_{n+1}) = \{\bar{P}_s\}$, i.e. the chip from position P_s will move to position \bar{P}_s . The process will be repeated until all modules transmit information to the station about the value of the measured parameters of their objects. For example, consider the process of connecting the 3rd module to a communication channel using a Petri net graph. The state of the 3rd module is reflected by the position P_3 .

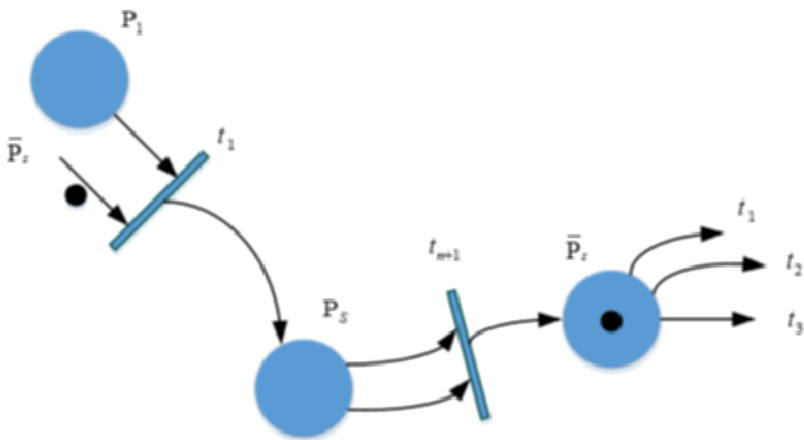


Fig. 2. A fragment of the Petri net graph at the completion of the information collection procedure by the first module.

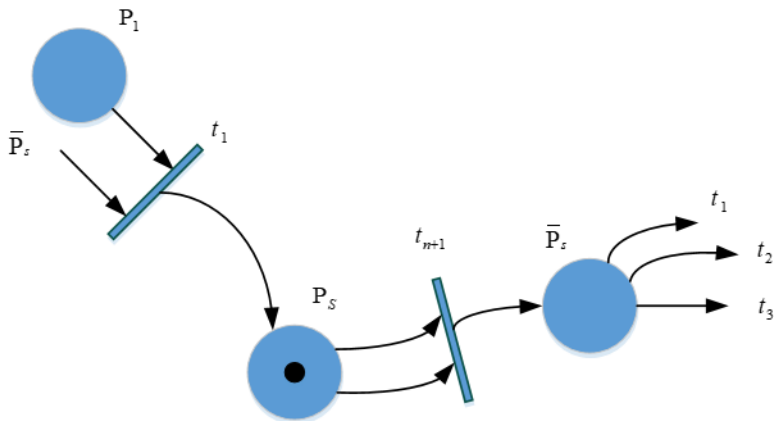


Fig. 3. Graph fragment during data transmission by the first module.

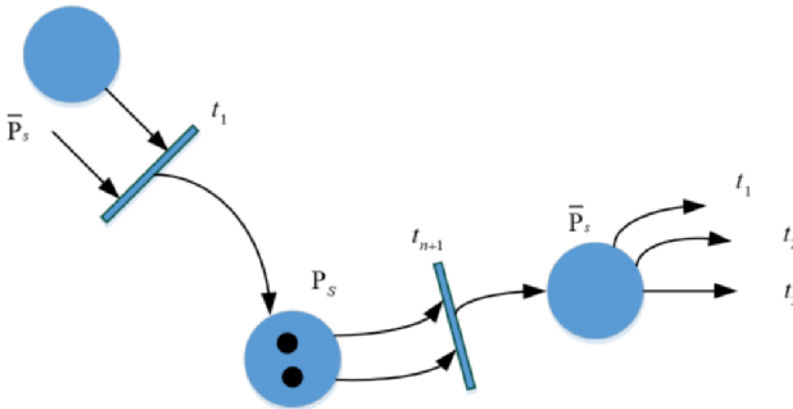


Fig. 4. Graph fragment at the end of data transfer.

When the procedure for measuring the state of an object is completed, three tokens will be placed in this position. This creates conditions for the execution of the output function $O(P_3) = \{t_3\}$ and the start of the transition t_3 , according to its input function (2) $I(t_3) = \{T_3, P_3, \overline{P_s}\}$. The conditions for the execution of this function are determined by the fact that the position has three tokens, the group distributor is in the third position, and at this point in time none of the remaining modules is occupied by the information transfer procedure. The launch of the t_3 transition will move the token to the P_s position, which corresponds to the transmission of information about the state of the third object to the station. The distribution of the time of using the channel for transmitting information by the modules in the considered case leads to a conflict situation, namely, when several modules are ready to transmit the results of measurements simultaneously.

To exclude this, a common group timer is introduced into the list of available modules, the position of which determines the right to transfer information of a particular object. The timer works cyclically, i.e. after reaching the position "T_n", the timer takes the next position "T₁", etc., while all the values of "T_i" at $i = 1 \dots n$ will be equal to each other [8-10].

In this case, the graph will have the following form Fig.5, and its system of input and output equations (2).

For the Petri net graph of the monitoring device Fig.5, extended input (I) and output (O) functions are given (2).

$$\begin{aligned}
 I(P_S) &= \{t_1, t_2, t_3 \dots t_n\}; & O(P_S) &= \{t_{n+1}\}; \\
 I(\bar{P}_S) &= \{t_{n+1}\}; P_n & O(\bar{P}_S) &= \{t_1, t_2, t_3 \dots t_n\}; \\
 & & O(P_1) &= \{t_1\}; \\
 & & O(P_2) &= \{t_2\}; \\
 & & O(P_3) &= \{t_3\}; \\
 & & \dots & \\
 & & O(P_n) &= \{t_n\}; & (2) \\
 I(t_1) &= \{T_1, P_1, \bar{P}_S\}; & O(t_1) &= \{P_S\}; \\
 I(t_2) &= \{T_2, P_2, \bar{P}_S\}; & O(t_2) &= \{P_S\}; \\
 I(t_3) &= \{T_3, P_3, \bar{P}_S\}; & O(t_3) &= \{P_S\}; \\
 \dots & & \dots & \\
 I(t_n) &= \{T_n, P_n, \bar{P}_S\}. & O(t_n) &= \{P_S\}; \\
 I(t_{n+1}) &= \{P_n\}. & O(t_{n+1}) &= \{\bar{P}_S\};
 \end{aligned}$$

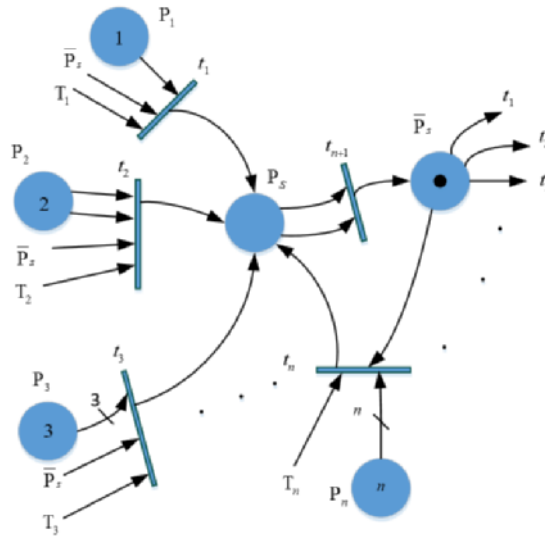


Fig. 5. Graph of the Petri net of the monitoring device, taking into account the operation of the group distributor.

As a result of the study of the model of the device for monitoring the signal point of auto-blocking, an algorithm for its operation has been developed, shown in Fig. 6.

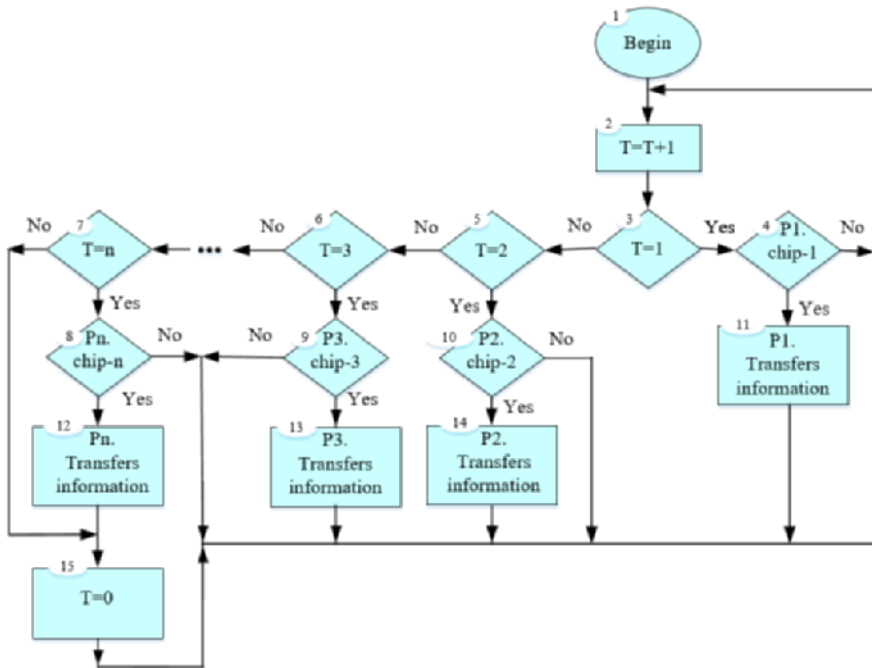


Fig. 6. Algorithm of operation of the monitoring device when organizing data transfer.

4 Conclusion

As a result of the considered methods for the implementation and study of the model, based on the theory of graphs, namely Petri nets, the device for monitoring the state of the equipment of the signal point of the numerical code auto-blocking system. The model uses a labeled graph, with chips placed in positions depending on the serial number of the information source. As a result of the study of the model, an optimal algorithm for implementing the procedure for organizing data transmission to the station from the signal point was obtained. A temporary method for dividing channels between modules is proposed, with a constant and equal value of providing a communication channel to each of the information sources.

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