Automation of the process of ensuring the safe movement of trains with the help of hardware and software complex.

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Abstract
Safety and continuity of train traffic is one of the main tasks of JSC "Russian Railways". Today, the number of negative factors affecting the railway infrastructure is increasing. The possibility of determining the probability of occurrence of a critical situation and reducing the time for its elimination is considered.
To solve this problem, the model of an ideal employee who provides the tasks of ensuring the safety of train traffic was described. This model was implemented in the form of hardware and software complex APK-PN. The use of the hardware complex allows you to ensure the fastest possible response of the operating personnel to the detected fault. Control of diagnostic parameters of devices is provided by integration with systems of technical diagnostics and monitoring. The prospects for the development of the complex are determined.

Keywords
train safety, hardware and software complex, neural networks, railway infrastructure, automatic troubleshooting, ideal employee, optimization.

1. Introduction

The safety of passengers and the safety of cargo is a top priority for every railway worker. Safe train traffic is provided by a serviceable and workable infrastructure. Increasing the speed of trains, reducing the intervals of movement, increasing the length and weight of trains increase the requirements for the reliability of infrastructure. At the same time, economic and human factors have a negative impact on the performance of the infrastructure. To save money, the service life of infrastructure facilities is increased, repair intervals are changed, cheaper materials are used, and the operating staff is optimized. The reduction of the operating staff and its low qualification affects the timeliness and quality of maintenance work, which can affect the safety and continuity of train traffic.

Despite the decrease in the number of transport accidents and other events committed on the railway transport infrastructure of JSC "Russian Railways" in 2019, the number of such events remains quite large. The task of reducing the number of failures and transport accidents remains the most important for the railway industry (Fig. 1) [1]. The task of reducing the number of failures and events remains the most important for the railway industry.

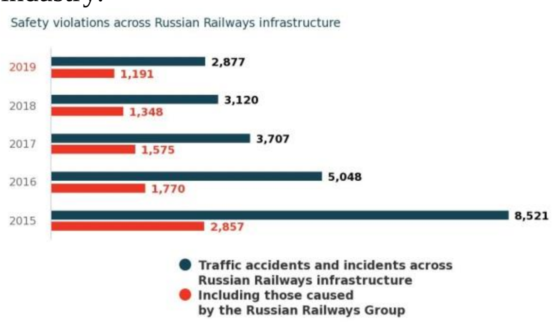

Figure 1: Safety breach statistics

Predicting the occurrence of a critical situation with an infrastructure object and

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carrying out preventive work can reduce the negative consequences.

2. The model of the ideal worker

When describing the model of an ideal employee who ensures the safety and continuity of train traffic, the following characteristics were obtained:

1. Having the necessary technical knowledge, the ability to clearly and quickly understand complex circuits and devices, constantly improving their knowledge.
2. Have knowledge and comply with all instructions.
3. Having sufficient experience and further developing it.
4. The most rapid response to a dangerous situation.
5. round-the-Clock and continuous work.
6. Control over all parameters of objects, universal coverage.

3. Hardware and software troubleshooting complex, as an ideal employee

Modern information and digital technologies make it possible to implement such a model in the form of a hardware and software complex. Based on the characteristics of the ideal employee, a hardware and software troubleshooting complex (APK-PN) has been developed.

The use of the hardware complex allows you to ensure round-the-clock operation and the fastest possible response to the detected malfunction. APK-PN is designed to automate the troubleshooting of railway automation and telemechanics devices, record the troubleshooting process, check the device's performance after troubleshooting and provide information to personnel [11].

Control of diagnostic parameters of devices is provided by integration with systems of technical diagnostics and monitoring. One of the most common systems of technical diagnostics and monitoring is the hardware and software complex of dispatching control (APK-DK) [2, 3], with which integration issues have been worked out.

To perform the declared functions of the APK-PN, the following diagnostic information from the APK-DK is required:

- values of diagnostic parameters of the failed control object;
- data on the train position at the time of manifestation of the fault of the object of control (free, closed or occupied track, track section involved in the route and determining the technological state of the object of control) [6].

The accumulation of data on the results of identifying the causes of failures is ensured by the fact that the APK-PN is developed on the basis of an automatic self-learning system, which is a multi-layer neural network built on a recurrent model. The reliability of the APK-PN increases with a gradual increase in the training sample during its operation [13.14].

The necessary regulatory and reference data are downloaded from the ACS-SH2 (automated system for managing the economy of centralization, signaling and blocking) and the ARM VTD (a set of software modules for maintaining technical documentation). Information about the reasons for failures is received from the ACS-SH2.

Technical documentation is downloaded from ARM-VTD:

- schematic diagrams of the failed device (current operational documentation);
- standard schematic diagram of the failed device (from standard design materials).

4. Structure of the information base

The structure of the information base of the APK PN system is shown in Fig. 2. The information base includes the following topics:

- a database of reference and regulatory information that is necessary for choosing a method for Troubleshooting railway automation and telemechanics devices (JAT);
- a database that includes information about the system and devices of JAT on stages and stations, as well as about the organization of operational work of the distance. The database information is necessary to create a communication Protocol with CTDM and ARM VTD, followed by the construction of a fault finding algorithm;

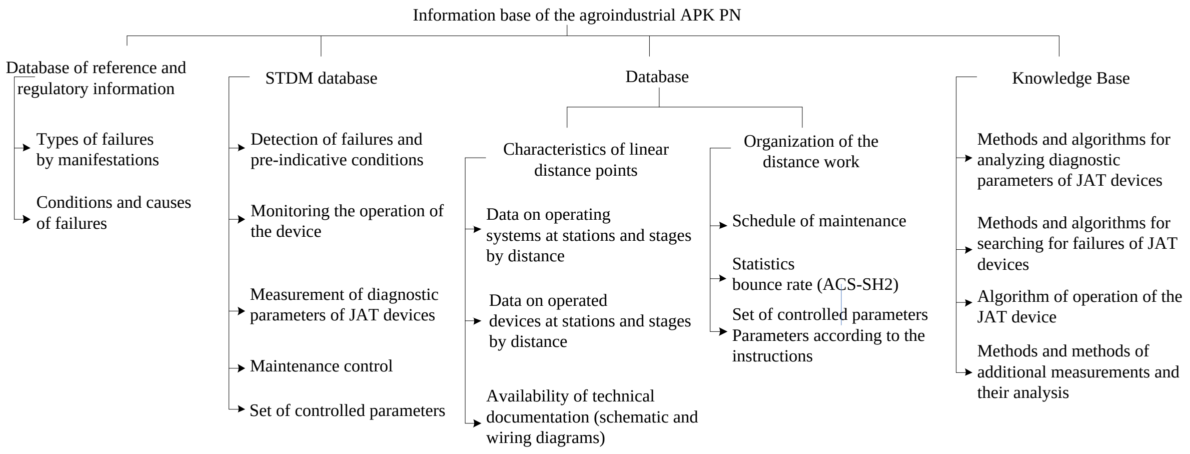

Figure 2: Information structure

- a knowledge base that includes: algorithms for the operation of JAT devices, existing methods for diagnosing, predicting the technical condition of JAT devices, methods for detecting and searching for failures, methods for conducting measurements.

5. Structure of the APK PN

The developed APK is a hardware and software complex that includes hardware and software. The software of the APK is built on the modular principle, it includes:

- interface for connecting to the APM-VTD short circuit;

- module for obtaining circuits from the ARM-VTD;

- module for connecting and displaying results in ARM VTD;

- module of choice of the failure class;

- module for building a fault finding algorithm, indicating the location of the equipment and devices of the JAT;

- module for displaying fault locations on diagrams;

- module for interactive display of the Troubleshooting algorithm, linked to the current technical documentation;

- module for saving the Troubleshooting Protocol;

- print module;

- hardware module for linking with the dispatching control system..

The composition of the technical means of the APK-PN includes a personal/ tablet computer.

6. Principle of operation of the APK PN

Figure 3 shows the functional structure of the interaction of AIC-PN with CTDM and ARM VTD.

The main components of APKPN are:

- module of interaction with 3 levels of CTDM (linear point of diagnostics, Central post, center of technical diagnostics and monitoring (CTDM));

- module for interaction with ARM VTD;

- a mobile measuring software package for performing additional measurements and obtaining fault finding algorithms.

Level 1 of the APK PN performs the following tasks and functions:

1. Implementation of additional measurements of diagnostic parameters of the control object.

2. Interaction with the CTDM:

- transfer the results of troubleshooting checks to the network printer.

3. Interaction with the Central point of building fault finding algorithms:

- getting troubleshooting algorithms;

- transmission of the results of additional measurements of the diagnostic parameters of the control object.

2 level APK PN should perform the following tasks and functions:

1. Interaction with information systems (APK-DK, ARM VTD):

- collection of diagnostic information from CTDM in the desired format;

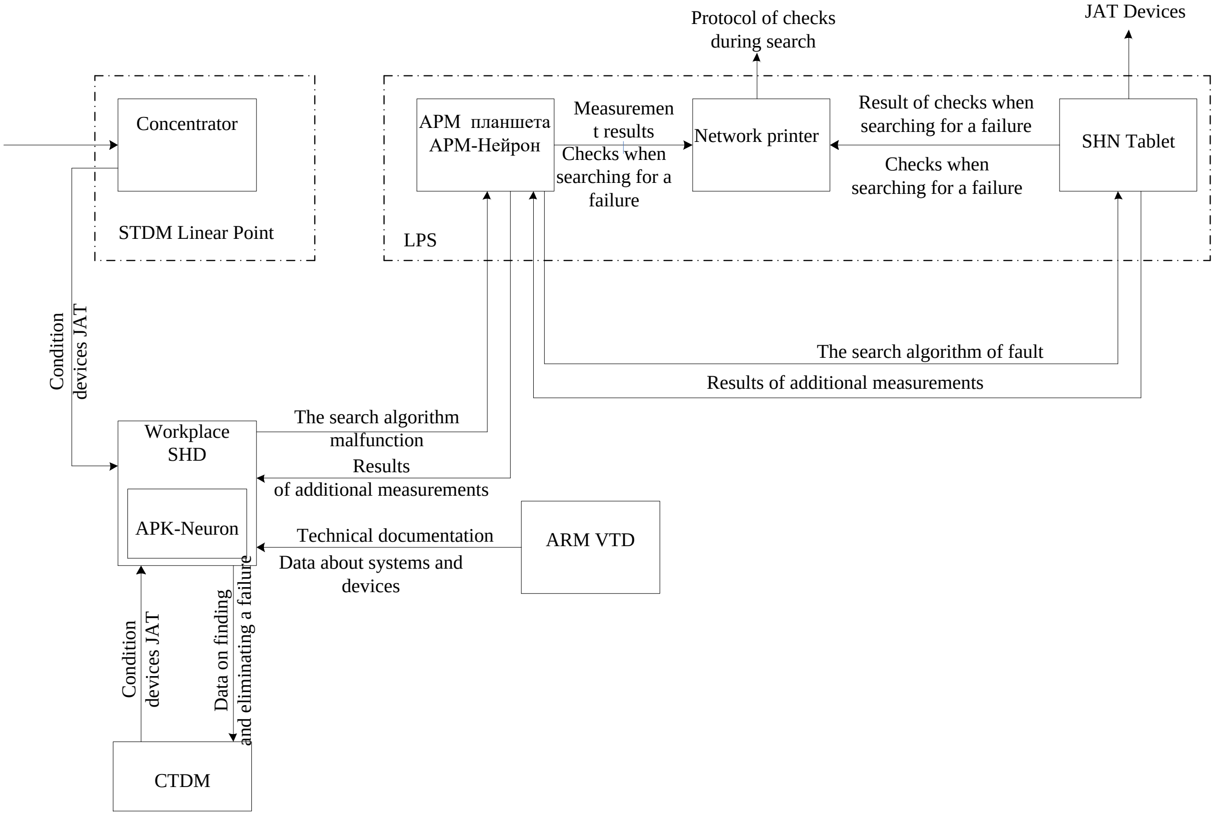

Figure 3: Functional structure

- download technical documentation from ARM VTD in the desired format;
- transfer of the built-in fault finding algorithms to the CTDM in the desired format;

2. Automation troubleshooting [17]:

- automatic analysis of diagnostic information and technical documentation;
- build and view Troubleshooting algorithms;
- long-term storage of constructed algorithms.

3. Detection of pre-failure States:

- issue of messages about the deviation of the normal operation of the control object;
- view information about deviations from the archive.

4. Interaction with LPS:

- transfer of algorithms to operational personnel on the mobile measuring complex in real time;
- receiving the results of additional measurements of diagnostic parameters of the control object.

After the manifestation of a malfunction of the JAT device, diagnostic information from the CTDM about the failed device should be transmitted to the APK PN. APK PN is part of the dispatcher's workplace and receives all diagnostic information both from the Central CTDM post on the basis of APK-DK, and from the center for technical diagnostics and monitoring.

After receiving the necessary information from the CTDM, a request is sent to the ARM VTD to obtain technical documentation of the faulty device (schematic diagrams).In the absence of technical documentation, a standard diagram for the corresponding system, in which the device is operated, is loaded on the failed device.

After receiving the full amount of information, the APK PN begins to synthesize the fault finding algorithm based on its knowledge base and provides a list of the minimum number of possible faulty elements in the sequence in which it is necessary to perform checks in order to reduce the search time (Fig. 4). In case of insufficient amount of diagnostic information to form a list of the minimum number of possible faulty elements, the APK PN synthesizes an algorithm for additional measurements of the diagnostic parameters of the device to reduce the search area and identify the faulty element. It also provides for the allocation of elements on the schematic diagrams of the device obtained from the ARM VTD, which must be checked and the points of additional measurements are indicated.

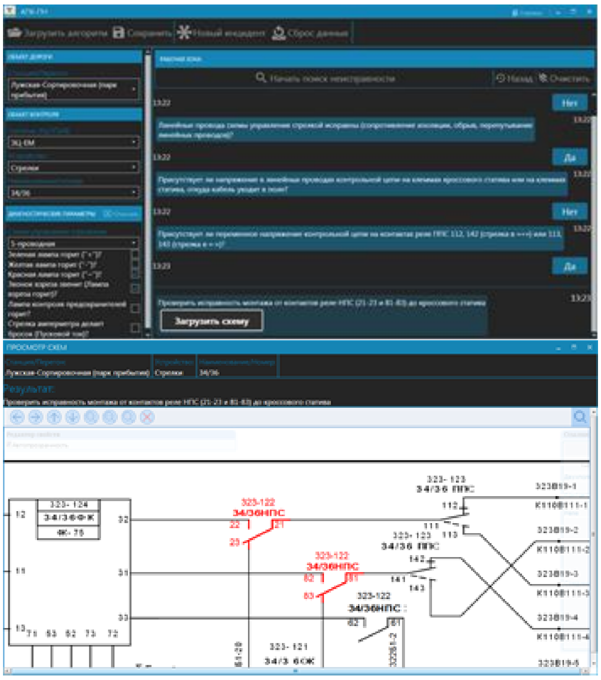

Figure 4: The program's interface

7. Prospects of development

Devices and systems for which system APK-PN has been conducting the construction of algorithms for Troubleshooting to date:

- switch device;
- station and the distillation of the track circuit;
- devices for monitoring the derailment of rolling stock;
- signal setting of numeric code auto-lock;
- change of direction scheme;
- ALSN;
- electrical centralization

APK-PN is an extensible system and it is possible to expand the database of fault finding algorithms for other railway infrastructure devices. Often, the cause of failures of devices and infrastructure systems are deviations in the operation of objects of adjacent farms. Therefore, the most promising areas of development of APC-PN is to obtain and analyze information from the largest number of diagnostic systems.

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