Model studies of systems with diagnostics based on fault simulation

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Abstract. The paper deals with the system diagnostics and search failures in the work of complex information systems. The question of using statistics to implement routing algorithms in the system is considered. The results of the experiment on defects detection of routing and control algorithms for information statistics devices are presented for the simulated system. Fuzzing technique is used to eliminate complex problems after failure detection. The set of requirements and components is defined for integrate node validation algorithms into the routing environment of the information system.

1. Introduction
Deployment of new information systems is a complex scientific and technical task. Defect in the device structure an information system capable of disrupting critical processes of human interaction [1]. At the same time, the operation and maintenance team of the information complex often doesn’t have data that the device is not available. To improve the exchange stability in real conditions it is necessary to automatically diagnose defects at the points of communication nodes.

The main problem of existing routing algorithms for complexes with a heterogeneous set of information transfer interfaces is consisted in the system behavior in case of failure. Having access to the device (communication node) by means of diagnostics and simulation of defect, the developer imitation emergency situations. The purpose of this article is to design an algorithm for diagnosing failures during communication for routing information complex, which includes operations for the analysis and correction of device components. We present the network structure for four types of data transfer points (figure 1), which has the means of technical diagnostics and fault detection. The technology network allows you to access statistics during communication sessions on devices to which diagnostic tools are connected.

The MJPS algorithm is used to select the interfaces that are most preferable for information transmission [2]. At application of a technological network the complex statistics operation in the conditions of reception and transmission information between nodes is formed. The network allows to perform expert diagnostics of devices (communication nodes) on the basis of signs to establish the correctness of the work.
To automate the detection of defects (manifested as system failures), which are software errors and hardware faults, the statistics of the information system is used.

2. Routing and diagnostics of defects in the information system
Statistics are collected during the operation of the system and are provided by MJPS algorithm, which accumulates a set of communication solutions for adaptive information transfer to the environment. The algorithm provides for the study of cases when information was lost during transmission between two nodes of the system (figure 2).

When routing or control program errors are detected fuzzing algorithms are used to eliminate defects.
The selection of features to generate statistics is an important step to obtain automatic defect detection [3]. In this case, the features were formed on the basis of expert evaluation of the system parameters that can be extracted during routing. The following data vectors were selected as data vectors to determine the correct operation of the device as part of the information system for the formation of statistics using the technological network [4]:

$$M_a = (m_{a1}^1, m_{a2}^2, \ldots, m_{aN}^N), n \in 1, N,$$

where $M_a$ - vector of memory addresses executed on the explore device at the time of connection of diagnostic tools;

$$W_s = (w_s^1, w_s^2, \ldots, w_s^n), n \in 0, \bar{1},$$

where $W_s$ - vector weather conditions for the time of the session, which is a qualitative characteristic (bad/good);

$$R_{int} = (r_{int}^1, r_{int}^2, \ldots, r_{int}^n), n \in 1, k,$$

where $R_{int}$ - vector select the type of data transfer interface during routing with the help of MJPS algorithm;

$$C_d = (c_d^1, c_d^2, \ldots, c_d^n), n \in 1, k,$$

where $C_d$ - vector of the transmitted data (gradation is selected small, medium or large set);

$$N_{tx} = (n_{tx}^1, n_{tx}^2, \ldots, n_{tx}^n), n \in 1, k,$$

where $N_{tx}$ - vector of transmitting device numbers;

$$N_{rx} = (n_{rx}^1, n_{rx}^2, \ldots, n_{rx}^n), n \in 1, k,$$

where $N_{rx}$ - vector of receiver numbers;

$$L_{time} = (l_{time}^1, l_{time}^2, \ldots, l_{time}^n), n \in 1, k,$$

where $L_{time}$ - vector of timestamps of the beginning of the session of exchange between devices;

$$Y_{res} = (y_{res}^1, y_{res}^2, \ldots, y_{res}^n), n \in 0, \bar{1},$$

where $Y_{res}$ - vector of session results.

The table of transfers between information system devices is given below (table 1). Table modeling is performed in Python for a given set of data vectors.

**Table 1.** The simulation results of the routing process.

| $Res$ | $N_{tx}$ | $N_{rx}$ | $C_d$  | $R_{int}$ | $W_s$  | $M_a$    | $L_{time}$       |
|-------|----------|----------|--------|-----------|--------|----------|-----------------|
| 0     | 9        | 7        | Average| 9         | Good   | 135121239| 2019-02-02 5:37:50|
| 1     | 6        | 5        | Small  | 3         | Good   | 134258225| 2018-04-03 22:19:37|
| 1     | 8        | 6        | Small  | 7         | Bad    | 135153655| 2019-07-22 13:46:23|
| 0     | 7        | 5        | Average| 7         | Good   | 134589502| 2018-10-16 3:43:39|
| 1     | 2        | 8        | Average| 5         | Bad    | 135071493| 2019-11-10 7:02:08|
| 1     | 7        | 1        | Small  | 6         | Good   | 134277113| 2018-09-22 9:06:26|
| 1     | 2        | 8        | Small  | 8         | Bad    | 134534935| 2019-09-29 9:54:51|
| 1     | 5        | 5        | Average| 2         | Good   | 135000506| 2018-10-31 17:24:29|
| 1     | 9        | 3        | Small  | 4         | Good   | 134890197| 2019-07-30 3:31:36|
| 0     | 3        | 3        | Small  | 1         | Good   | 134332480| 2019-06-05 22:45:28|
3. Modeling the results of the information system exchange process
For the obtained statistics, we build a set of rules for classification. For construction we use algorithms of decision trees which are a part of algorithms of ranking and data processing (boosting, bagging methods) [5,6]. The visualization shows that the data are divided into about five to seven large groups by distinctive features (figure 3). For high-level groups of nodes, positive solutions are indicated in green, negative solutions in red, while traversing the tree in depth, white and purple colors are additionally used, respectively.

![Figure 3. Visualization of decision tree for simulated network statistics.](image)

The decision tree allowed to obtain a numerical characteristic of the dependence of data vectors. This is done for $\text{Imp}(X_m)$ using Gini importance [5]. As a result of modeling it is found out that the exchange process depends on $M_a$ most of all. This is because the failure handler address for devices is in a different address space (figure 4).

![Figure 4. The dependence of the result of the communications session from the data vectors.](image)

Table 3 shows the results of the analysis of simulated failures. The results are grouped into defect groups. A preliminary set of statistics was formed from data vectors, for which the defect was assigned to the specified classes according to the results of fuzzing. Simulated sessions with defects were detected correctly. The localization defect parameter specifies one of the three main defect
groups (algorithm routing, control program errors – node management and hardware interface error). The number of detections indicator informs about the recurrence of this error in the simulated data.

Table 2. The experiment results for the analysis of a simulated defect.

| No. | Defect localization | Defect description                        | Count fixes |
|-----|---------------------|-------------------------------------------|-------------|
| 1   | Routing table (T-class) | Incorrect selection of intermediate node | 12          |
|     |                     | Information lost                           | 7           |
| 2   |                    | Transmission time delay                    | 10          |
| 3   | System node management (S-class) | Control system failure            | 3           |
| 4   |                    | Violation of the routing table             | 1           |
| 5   |                    | The distortion of the transmission time    | 5           |
| 6   |                    | Interface failure during transmission      | 3           |
| 7   | Routing interfaces (I-class) | The failure of the interface and re-transmitting | 7           |

Based on the data obtained, it is worth noting that the software needs to be improved, as can be seen from the graph depending on the transmission parameters.

4. Conclusion
The algorithm applicable together with routing for defects search in information systems was created with collected and processed statistics of nodes and software testing algorithms. It assumes the subsequent analysis together with methods of fuzzing [7, 8] for devices which defects are connected with program errors or software and hardware malfunctions for their operative elimination by group of development, operation and maintenance of the developed information system [9].

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