Regarding Information Systems Dependability Analysis

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***Abstract*—The article presents classification of information systems by different parameters. Factors influencing information systems dependability are also presented. The article describes the strategy of information systems dependability analysis and methods of its increase. The example of analysis of real information system is considered to show how to implement the strategy.**

***Keywords*: information system, dependability, maintainability, reparability, integrated logistics support, structural and functional analysis.**

I. Introduction

Nowadays information systems perform different tasks almost in all fields of human activity. Their responsibility increase rapidly for the last time. For that reason, providing the information systems dependability becomes more and more important.

The aims of research are the information systems dependability estimation criteria determination and dependability increasing methods development.

We consider the information system as a hardware system. The software of this system is considered as the component, which provides working of the system, and delivers a human-machine interface. The special attention is paid to hardware dependability.

In this report, we will consider information systems as a whole and highlight their features. We will also describe the generic algorithm of information systems dependability analysis and give the methods of dependability increase.

As a main dependability definition, we use the definition given in the standards IEC 60050-191:1990 [1] and IEC 60300-3-1:2003 [2].

In this term, availability performance is the ability of an item to be in a state to perform a required function under given conditions at a given instant of time or over a given time interval, assuming that the required external resources are provided.

Reliability performance is the ability of an item to perform a required function under given conditions for a given time interval.

Maintainability performance is the ability of an item under given conditions of use, to be retired in, or restored to, a state in which it can perform a required function when maintenance is performed under given conditions and using stated procedures and resources.

Maintenance support performance is the ability of a maintenance organization, under given conditions, to provide upon demand, the resources required to maintain an item, under a given maintenance policy.

The given conditions in these definitions are related to the item itself and to the conditions under which the item is used and maintained.

II. Object Analysis

The generic structure of the information system can be presented as a three-level model (Fig. 1).

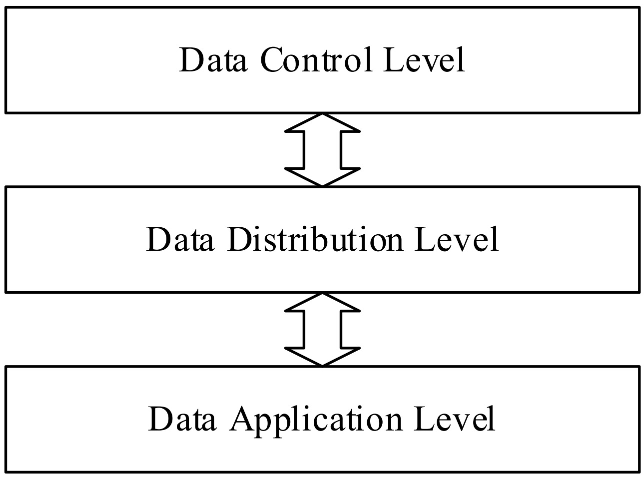

Fig. 1. Information systems generic structure

Upper level is responsible for working of IT-infrastructure. The centralized data processing, general-system services delivering, data storage and shared resources control are performed here. This level also provides data integrity and safety.

Middle level provides safe data transmission, data integrity control during the transmission and data routing.

Lower level provides client workstations and peripherals working.

Every level has a specific structure and performs different tasks; therefore, it is necessary to study working of these levels separately.

Moreover, every real implementation of the information system has specific parameters. Every specific parameter needs additional studying.

It is impossible to describe all variants of information systems implementation. So that, let's try to classify these implementations according to different parameters. After that one can present the most common specifics and regularities of real information systems in each class.

The information systems can be classified by following parameters:

a) On geographical distribution:
- Distributed systems;
- Centralized systems.

b) On performed tasks:
- Corporate Networks;
- Data processing centers.
- Information systems of network providers.

c) On application field:
- Industrial information systems;
- Administrative Information systems;
- Information systems included both industrial and administrative levels.

Distributed information systems are located in several buildings. The system consists of several segments. This type of systems usually has central segment placed in the main building and a number of local segments, which are able to work independently from each other. Central segment equipment delivers general services such as connection between segments, providing access to the Internet and others. If the central segment equipment fails, other segments are not able to use general services but are still able to perform local operations. The most critical levels in these systems are central data control level and central data distribution level. Its dependability must be higher than dependability of other ones. The failures of central data application level may not cause general functions failures and do not affect working of other segments but in this case central layer administrators may lose control of the system. Therefore, its dependability has to be higher as well.

The structure of centralized information system can be presented as one local segment of distributed information system.

The purpose of corporate networks is to support users working. Hence, the tasks of data application level determine the structure and functions of these systems. This layer is usually the largest one in this system.

The data processing centers are high-performance systems, which perform complex operations with the large amount of data. The tasks of data control level determine its structure and functions.

The data distribution level can be conventionally divided into internal (which provides communication between data center servers) and external (which connects the data center and external users) levels.

In these centers, it may be no data application level for example if the data center performs the cloud computing.

The main task of the information systems of network providers is to provide data transmission. There is no data application level in this type of information systems. Its structure and functions are defined by the data distribution level, and the task of data control level is to distribute information between clients according to their requests.

The industrial information systems are usually real-time systems. They provide working of automated control systems. These systems deliver the human-machine interface and allow controlling real state of the technological process. They are critical systems. Their failures may cause massive destruction or any more critical aftermaths. So that, these systems must have high dependability and long lifetime.

The administrative information systems are not real-time systems. These systems support office working and their failures are not so critical as industrial information systems failures. The faults of them may cause economic loses but usually not affect human health and life and not cause massive destruction. Therefore, the dependability of these systems depends on aftermath scale caused by their failures.

III. Information Systems Dependability Factors Analyzing

After information systems analyzing let's study the factors influencing information systems dependability.

These factors are divided into internal and external ones.

1) The internal factors are:
- Elements dependability;
- Amount of elements;
- Elements joining method.

2) The external factors are:
- Environmental conditions;
- Usage strategy (including usage time and intensity, user's qualification, work organization);
- System structure;
- Software used.

The internal factors affect working of information system equipment and the external factors affect working of information system as a whole.

The analysis of studies in the field of microelectronics and computing equipment dependability [3]-[7] showed that there are quite different methods of eliminating every concrete factor. The analysis of different examples of real information systems implementations [8][9] provides distinguish three basic groups of arrangements used to eliminate influence of described factors:

1) Technological arrangements that increase the system dependability using the maintenance and repair policy.

2) Organization arrangements, that allow increasing dependability by changing usage strategy (e.g. by optimizing usage time and intensity or employing more qualified specialists).

3) Arrangements on structure optimization, that increase dependability due to changing of system structure.

On this step, the problem of arrangement choosing is faced. It is also necessary to have to develop the concrete methods of implementing these arrangements in real information systems.

To solving these problems the strategy of information systems dependability analysis and methods of its increase are developed. If data are to be reliable, the instrumentation used has to be reliable too [10].

The algorithm has iterative structure. The amount of iterations depends on amount of functions and priorities. This algorithm is the implementation of the integrated logistics support (ILS) methodic for information systems.

The first part of this algorithm corresponds to the Failure Modes, Effects and Criticality Analysis (FMECA) procedure [11]. (Fig. 2).

Using the accumulated statistics corresponding to the separate junctions of a system, each type of the system component can be related to a definite law of failure intensity, assuming the latter to be a constant value at minimum statistics. The influence of external unfavorable factors on the system in this case cannot be determined; thus, the distribution law and its parameters cannot be correctly obtained either. Use of the guide data corresponding to the analogs of the system components may be a way out of this situation. Knowledge of the dependability component does not provide information concerning the dependability of the system as a whole. For analyzing the system one should know its structure and inner functional connections. In structural design, the dependability of a structural component is evaluated with respect to one or more failure modes. There are a lot of methods for constructing failure models of complex systems [12]. One of the approaches for models under incomplete information based on the set of canonical analytical expressions for computing imprecise structural reliability has been obtained by Lev V.Utkin, and Igor O.Kozine [13].

The second part implements the reliability centered maintenance including condition based monitoring procedure [11]. The latter task entails selection of the servicing system, development of control and diagnostics systems, processing and analysis the data for obtaining information on performance quality, carrying out various stages of maintenance according to technical and economy criteria, and increasing the quality of reconstruction [14]-[17].

The third part defines the profitability of arrangements to be determined [2][5][14]. The arrangements planning and implementation are also performed in this part.

One can use this algorithm in case of a small enterprise budget and having problems with working of IT-infrastructure. It may be problems with a low data transmission time in the network or frequent failures of the network equipment. So, this is the most general algorithm.

There is the task of implementing this algorithm for solving real systems problems. For this purpose, it is necessary to describe formally all procedures of this algorithm as applied to information systems.

It is also need to develop concrete realization methods of these algorithm positions, which allow solving real problems.

Let's describe only the structural and functional analysis methods for information systems. Let's consider these methods on the example of the Microprocessor Units of Automation chair infrastructure in the Perm National Research Polytechnic University. The hardware structure of this system is shown on Fig. 3.

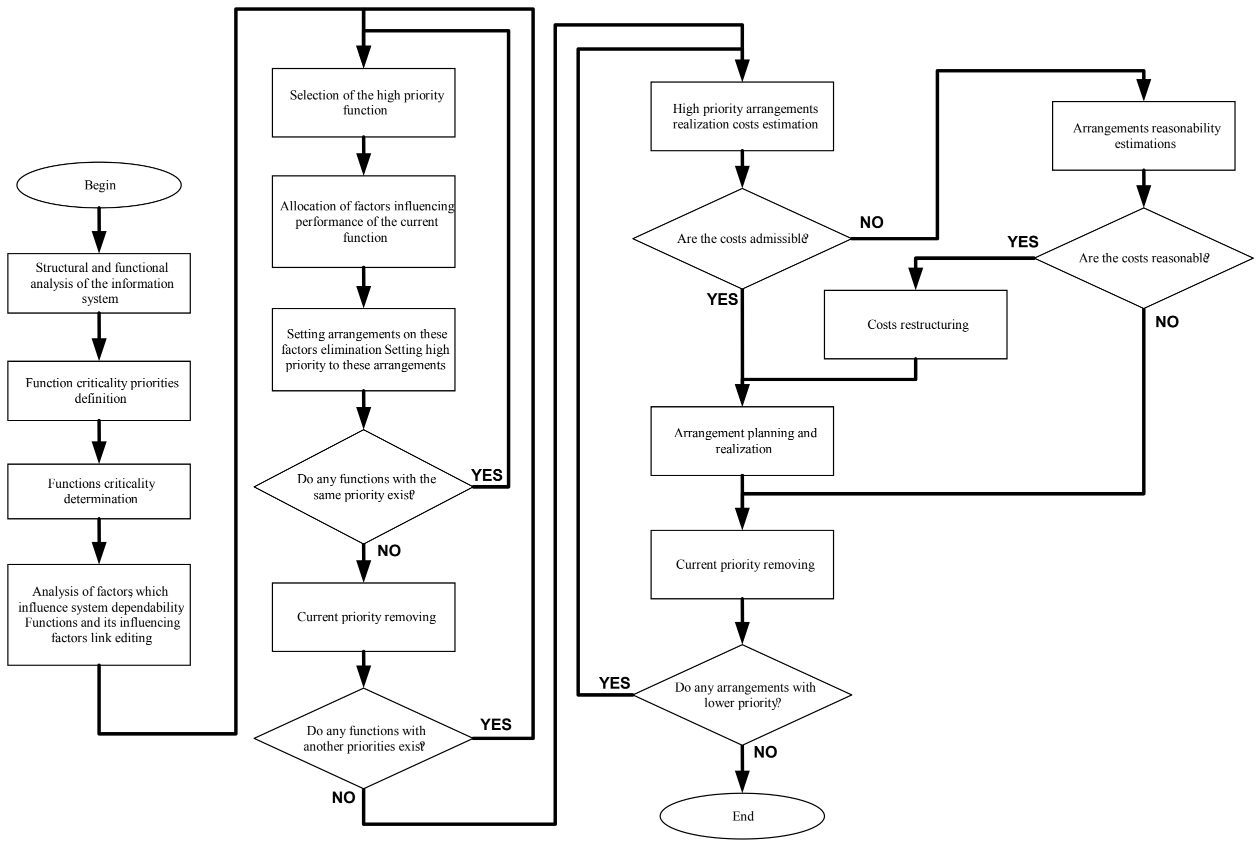

Fig. 2. The strategy of information systems analysis and their dependability increasing methods choosing

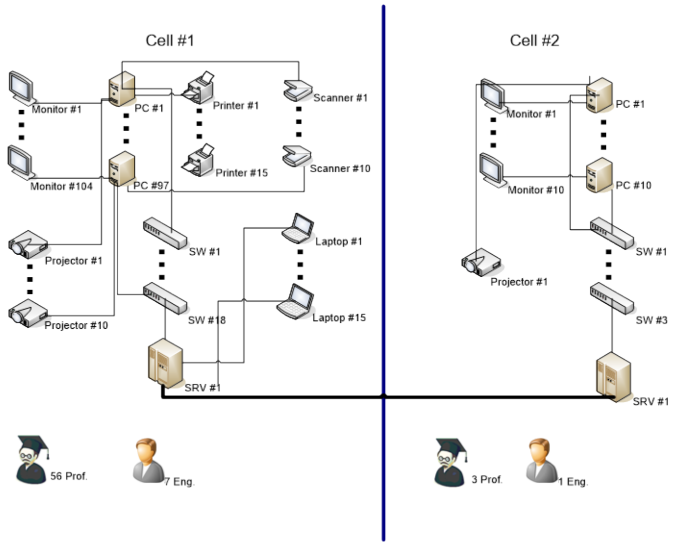

Fig. 3. The IT-infrastructure of the Microprocessor Units of Automation chair in Perm National Research Polytechnic University

The system consists of two segments. The main segment supports working environment for fifty six professors. Seven engineers provide technical support, maintenance and repair of the system. The second segment supports working environment for three professors and maintained by one engineer.

The detailed structure of this information system is shown on Fig. 4.

The PCs and servers are detailed into their internal replaceable modules but network equipment and peripherals are detailed into concrete devices due to repairing them in service centers.

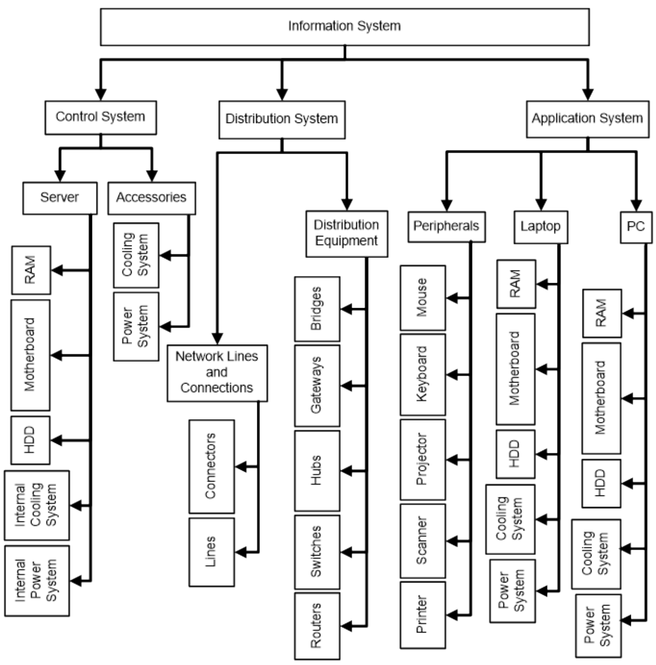

Fig. 4. Information system detailed structure

The functional structure of the information systems is determined by its software. The basic software used in the chair's information systemis shown on the Fig. 5.

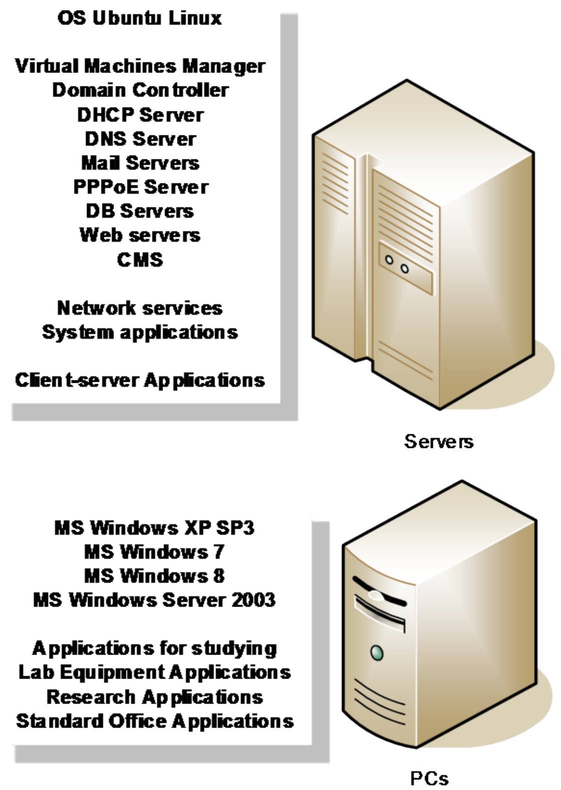

Fig. 5. Software used on the chair's information system

On the described system, there are organization problems on all levels. For example: there are no technical descriptions and schemes of this system, there are no concrete usage rules, which makes impossible to support this system. There also structural problems (the network structure do not provide stable interconnection between equipment). There are some technological problems because of some equipment is very old.

IV. Conclusion

This example illustrated the implementation of the first part of the algorithm described previously. In future, we plan to develop implementation methods for all steps of the algorithm. The experimental analysis of our chair information system using this algorithm will be carried out. It is also necessary to generalize the described strategy on all information systems classes. The task is to find concrete enterprises with different types of information systems to conduct more experiments and test this strategy in real conditions.

Works on this direction are conducted within the Russian Foundation for Basic Research Grant of Russia No 14-07-96000 "Development of an intellectual decision support system to ensure of energy facilities trouble-free operation".

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