Automation of full-scale regression testing of radio monitoring equipment

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Abstract. Modern means of radio monitoring (RM) are complex hardware and software systems based on SDR (Software-defined Radio) technology. The software (SW) modernization of RM complexes requires the parallel work of large teams of developers. Introducing insufficiently coordinated changes in the software is accompanied by the risk of conflicts, failures and other side effects in the long-used software elements. In this case, failures do not always manifest themselves on mathematical models of systems, and sometimes they are found only in the framework of field tests. Delays in detecting such failures can significantly slow down the process of software modernization; therefore, it is very important for developers of RM tools to have a mechanism for the fastest and most accurate detection of problem situations that accompany the operation of equipment in real-life conditions. Recommendations on the creation of a mechanism for regression testing the performance of RM tools are given in this article. This mechanism is based on the development of a set of tests for a system that automatically controls both the item to be checked and the monitoring, signal-generating and measuring equipment, and is capable of interacting with the interface modules of the RM complexes without operator intervention. It is shown that the proposed testing methodology allows several times reducing the time spent searching for problematic situations of the functioning of RM in real operating conditions.

1. Introduction

The need to transmit more and more information is forcing manufacturers of communication and data transmission systems to introduce new, more advanced and powerful means of data transfer based on constantly improving communication standards. With regard to wireless communication systems, the rapid growth in the number of coexisting on-air means and systems greatly increases the risk of mutual interference. The basis for the identification and elimination of such conflicts are modern radio monitoring tools (RM), which also need constant modernization and updating of their capabilities. Modern tools of the Republic of Moldova, as a rule, are based on SDR (Software-defined Radio) technology and their improvement primarily involves the modernization of the software embedded in them. Development and debugging of new software is a complex and multifaceted process, in which tens and hundreds of developers participate in parallel and some changes are made almost daily. At the same time, to verify the correctness of new solutions, or, conversely, to identify the conditions under which the upgraded software may fail or not work reliably enough can be possible only in the
framework of field tests. This fact indicates the need to use specialized testing mechanisms for continuously updated software and efficient debugging of new functionality of RM tools.

It should be noted that the verification of the correct operation of the new functional capabilities of RM tools can hardly be automated; such testing can only be done by the hardware developers themselves. However, a detailed check by developers of new equipment capabilities, as a rule, allows identifying a relatively small set of tests that confirm or refute the correct operation of RM tool. The selection of such a set of tests can serve as the basis for the development of a regression testing procedure, which is understood as the periodic re-testing of the functionality of previously debugged functionality. Considering the complexity and versatility of the functions implemented in modern means of the Republic of Moldova, the implementation of such a process "manually" will require significant time and labor resources, and may also be accompanied by inaccuracies generated by the human factor. But regular regression testing using an automated system can be a very effective mechanism for finding problematic options for the functioning of RM complexes.

2. Methods of testing radio monitoring equipment and its specific features

It should be noted that in relation to the development and debugging of various software products, regression testing is a fairly well-known mechanism for increasing the efficiency of development teams. The use of regression testing for the modernization of hardware and software systems has a number of features. Its effective use is inextricably linked with the possibility of placing the equipment under test in a radio environment that most closely matches the physical operating conditions of the equipment. To do this, it is advisable to use either an anechoic chamber or a room well shielded from third-party radio emissions, in which, using a combination of programmable generators and a set of emitting antennas, an imitation of close to real-processed electromagnetic fields can be created. A fairly extensive set of tests can also be organized by directly connecting the signal generator to the input of the tested complexes of the Republic of Moldova.

As a control basis for testing organization, such environments / software packages as TestComplete [1], Selenium [2] can be recommended. Preparation for testing implementation involves the preliminary writing of a set of scripts that reflect the actions of a tester when “manually” performing groups of critical tests identified during the development of RM complex and testing the features of its operation. There are several types of automated testing: low-level Unit tests that test individual procedures, mid-level tests (API tests) that check the interaciton between software blocks, and user interface interaction tests (GUI) tests.

GUI tests, in comparison with other types, allow carrying out comprehensive testing. And in conditions when the object of the study is a hardware-software complex, such a check allows identifying not only the problems of interaction of software components, but also verifying the correct functioning of the links between the software and RM hardware. Accordingly, such tests are most effective. The automation system used (for example, TestComplete) provides access “from within the tests” to the interface elements displayed on the screen, and the execution of a sequence of actions specified in a script and comparison of the result with the “predefined” one during test development allows the automated system to make correct decisions about the success of the test, or about the discovery of a situation in which the correct operation of RM complex was violated.

One of the criteria for a well-designed test is repeatability. This means that the surrounding reality should not affect the course of the audit. In particular, when checking the possibilities of processing RM equipment with radio signals of various standards, it is inappropriate to use off-the-air signals generated by third-party equipment; instead, create and use a “bank” of analyzed signals. A similar approach can be implemented using a vector generator. For example, Agilent E4438C generator provides this capability through special SCPI (Standard Commands for Programmable Instruments) commands received over TCP/IP. The structural diagram of the test system bench is shown in figure 1.
Currently, the implementation of automated testing is one of the important stages of the software development process at the scientific and production company IRCOS JSC. The process is structured as follows. During a working day, developers make changes to the software components, and at night the automated testing system collects and deploys a new version of the software and conducts its regression testing. Figure 2 shows a report with the test result.

3. An example of the implementation of testing the frequency measurement subsystem using automation

For a more detailed description of the testing process, an automated verification of the signal frequency measurement subsystem as part of Argamak-IS complex will be considered [3]. In this case, what is needed is to make sure that the frequency of the harmonic signal is determined by PM complex with the required accuracy. This test affects the operation of the analog and digital components of the radio receiver, as well as a number of calculations performed on the PC, completing the measurement procedure [4]. It should be noted that with the complex architecture of the used radio receivers, the correct functioning of the measurement subsystem at one or several frequencies does not guarantee the operability of RM complex at other frequencies, however, this does not present significant difficulties in the development of tests, since automation makes it easy to carry out the verification procedure for an extensive set frequencies.
The measurement verification process for each frequency from the list is carried out under the control of an automated testing system and consists of the following steps:
1) Tuning the generator to the measurement frequency using SCPI commands.
2) Tuning the software measurement subsystem to the same frequency.
3) Measurement of signal frequency.

Scripts for automated tests are being developed at IRCOS JSC using behavior-driven development (BDD) technology. The essence of this technology is to describe the test in a natural language. Initially, test developers in an interpreted programming language describe basic operations. Then each basic operation acts as a “block” in the composition of the final test (figure 3).

![Figure 3. A “block” in the composition of the final test.](image_url)

The above script has high stability, since it takes into account the various initial states of the system and pre-configures the application before starting testing the frequency measurement subsystem.

4. **Benefits provided by automated testing technology**

According to the results of implementation, the following positive features of the application of the testing system can be distinguished:
1. The speed of testing is increasing. For example, in the case of manual testing, it takes 10 hours for a specialist to pass one set of tests, and an automated system can cope with this task in 2.5 hours.
2. The burden on testing specialists is reduced. Since the system is fully automated, human intervention is required only for routine maintenance to update development and automation environments. A plus is also the testing at night, which allows using expensive generators in the daytime for development and research.
3. The time required to prepare the final version of the software is reduced. In the case of manual testing for checks of the most important areas of one project, at least one working day is required. If there are several projects, the time for testing increases by a multiple of the number of projects. In the case of automated testing, you can get confirmation of the software’s performance even the next day after making the changes.
4. Increases test coverage. In the conditions of automated verification, it is not difficult to expand the scope of inspections by repeatedly repeating tests for variable input data.

The negative aspects include only the complexity of developing a test system and the potential need to make changes after global software revisions. However, despite this feature, the automated testing system as a whole can significantly increase the efficiency of developing high-quality and reliable software for RM complexes.

5. **Conclusion**

Software modernization of modern radio monitoring tools (RM) is a laborious and complex process that has been carried out for months and even years by large teams of developers. Such processes are inevitably accompanied by the appearance of errors, and along with errors that can be identified using
mathematical models of processes and devices; there are errors that appear only during the actual operation of RM tools. To increase the efficiency of developing RM tools, a mechanism is needed for the timely (as quick as possible) detection of such errors.

The technology proposed for the organization of full-scale regression testing of RM complexes is based on:

- using BDD technology in the TestComplete development environment;
- provided by many modern devices and, in particular, remote control signal generators;
- work with the “bank” of radio signals to ensure repeatability of results;
- the use of real radio channels, including real physical signal sources.

This technology allows performing regression testing in the shortest possible time without distracting specialists from the development process, fully take into account all the nuances of the work of RM complexes and ensure their quick and complete testing. The presented testing technology allows minimizing the impact on the results of testing the human factor, providing multiple testing of the functionality of RM complex for a very wide range of settings, and also significantly accelerating the testing process.

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