Selection of virtual and real interface lines when testing automated process control systems

Asgarova Bahar, Almammadova Mehriban, Kameneva Nina.

Abstract

The introduction of automated process control systems in all areas of production requires their preliminary tests using various types of simulation. The article proposes a test method based on the synthesis of simulation and physical modeling of the work of control objects of systems, performed by program-spatial differentiation between virtual and real interface data exchange lines between information subsystems. The method of isolated channels is applicable to automated process control systems (APCS), the lower level of which includes multi-channel (redundant) control and monitoring devices for sensors and actuators. The method of reservation in this case can be arbitrary, which determined by the purpose of the reservation. The method of reservation in this case can be arbitrary, which determined by the purpose of the reservation. In connection with the use of redundancy of various types of devices of all levels in terms of safety and reliability for most process control systems, the potential prevalence of this method can be very wide [2, 5]. The method of isolated channels involves the division of interaction for a part of the channels of individual objects or groups of lower-level objects in such a way that some of the channels interact with the simulation model, and the other with real lower-level controllers. Thus, when implementing this method, the selected objects interact through one information (control) channel with simulated drivers, and through another - with real ones (Fig. 1). Thus, when implementing this method, from all M + N channels of the redundant controller of a certain lower-level process control system, the program modules of M channels interact through real interface drivers with the physical channels (the number is M) of this controller, and the remaining program modules of N channels interact with the corresponding modules (processes) of the simulation model that simulate the operation of these channels (through simulated drivers).

Keywords: computer-aided design, specialized software, tests, control system for arrows and signals, controller

This method is not used as an independent tool, but is used in combination with the method of isolated groups or the method of isolated objects (or with both of these methods).

When using the method of separate channels in combination with the method of separate groups, one channel of the group of objects as a whole interacts with the simulation model, and the other channel of the group interacts with lower-level object controllers (without splitting the groups and separating individual objects from them).

In this case, the access scheme to connection points of interface drivers for various channels of groups of objects, using the example of a process control system with four groups of objects controlled by two-channel controllers with an arbitrary redundancy method, has the following form:

LINE 1 [connection address of the driver of the 1st group of the 1st channel] >> {real driver}
LINE 2 [connection address of the driver of the 1st group of the 2nd channel] >> {simulated driver}
LINE 3 --
LINE 4 --
LINE 5 [connection address of the driver of the m-th group of the 1st channel] >> {real driver}
LINE 6 [connection address of the m-th group driver of the 2nd channel] >> {simulated driver}
LINE 7 --
LINE 8 --

Interaction with real and simulated drivers organized in a similar way for controllers with an arbitrary number of channels and for an arbitrary number of groups of objects. The method can applied in this case to one or more groups of objects.

When using the method of separate channels in combination with the method of separate objects, in the general case, each group of objects divided according to the following principle - for all N+M+K objects of the group:

- For N objects, interaction organized only with the simulation model via both channels;
- For M objects, interaction is organized only with the corresponding lower-level controllers via both channels;
- For K objects, interaction with the simulation model is organized through one channel and with lower-level controllers through another.

In this case, the access scheme to the drivers of the real and virtual interface line, using the example of objects with two-channel controllers in the presence of four groups of management and control objects (MCO) in the system, has the following form:

LINE 1 [connection address of the driver of the 1st group of the 1st channel] >> {real driver}
LINE 2 [connection address of the driver of the 1st group of the 2nd channel] >> {real driver}
LINE 3 [connection address of the driver of the 1st group of the 1st channel] >> {simulated driver}
LINE 4 [address of connection of the driver of the 1st group of the 2nd channel] >> {simulated driver}
LINE 5 [connection address of the driver of the 1st group of the 1st channel] >> {real driver}
LINE 6 [connection address of the driver of the 1st group of the 2nd channel] >> {simulated driver}
LINE 7 [connection address of the driver of the 2nd group of the 1st channel] >> {real driver}
LINE 8 [address of connection of the driver of the 2nd group of the 2nd channel] >> {real driver}
LINE 9 [address of connection of the driver of the 2nd group of the 1st channel] >> {simulated driver}
LINE 10 [connection address of the 2nd group 2nd channel driver] >> {simulated driver}
LINE 11 [connection address of the driver of the 2nd group of the 1st channel] >> {real driver}
LINE 12 [connection address of the 2nd group 2nd channel driver] >> {simulated driver}
LINE 13 [connection address of the driver of the 3rd group of the 1st channel] >> {real driver}
LINE 14 [address of connection of the driver of the 3rd group of the 2nd channel] >> {real driver}
LINE 15 [connection address of the 3rd group 1st channel driver] >> {simulated driver}
LINE 16 [address of connection of the driver of the 3rd group of the 2nd channel] >> {simulated driver}
LINE 17 [connection address of the driver of the 3rd group of the 1st channel] >> {real driver}
LINE 18 [connection address of the 3rd group 2nd channel driver] >> {simulated driver}
LINE 19 [connection address of the driver of the 4th group of the 1st channel] >> {real driver}
LINE 20 [connection address of the driver of the 4th group of the 2nd channel] >> {real driver}
LINE 21 [address of connection of the driver of the 4th group of the 1st channel] >> {simulated driver}
LINE 22 [address of connection of the driver of the 4th group of the 2nd channel] >> {simulated driver}
LINE 23 [connection address of the driver of the 4th group of the 1st channel] >> {real driver}
LINE 24 [address of connection of the driver of the 4th group of the 2nd channel] >> {simulated driver}

Interaction with an arbitrary number of groups for controllers with an arbitrary number of channels organized in a similar way. In particular, cases, this scheme can simplified by splitting not all, but only part of the groups of objects into subgroups M, N.

Using the method of separate channels in combination with both methods of separate groups and objects involves splitting some groups into subgroups M, N, K; for some groups, organizing the interaction of one channel of the group as a whole with simulated drivers, and the other with real drivers. Some groups can interact as a whole either with a simulation model or with real lower-level hardware.

The main purpose of tests using the separate channels method is to verify the fulfillment of the conditions for redundant processing of control information in the complex interaction of all components of the automated process control system. Application of the method involves simulating data discrepancies in the channel interacting with the modules of the simulation model, with the channel interacting with hardware components (the corresponding channel of the lower-level object controller). In this case, all possible

combinations of states established on both channels within the capabilities of setting the channel states of real lower-level controllers and the simulation model.
In this case, the simulation model makes is possible to simulate such states of the controlled channel, which are not possible to establish for a real controller using physical mock-ups or are fundamentally difficult (for example, simulating sending a code for unauthorized activation of a more permissive indication at a traffic light, self-propelled switch motor, differences in switch states in extreme positions, etc.).The use of the method of separate channels in combination with the method of separate objects ensures the implementation of the most complete set of checks of automated process control systems in the complex of interaction of constituent components, covering not only all technological situations, but also the maximum number of technical conditions of objects. This is the main advantage of this method.
The most rational application of the isolated channel method in combination with the isolated object method is the formation of a test complex in which:
- for each group of objects, one object of the corresponding category (subgroup) is connected to the test complex, for which it is divided into channels interacting with different drivers (real and simulated), but for the other object - not;
- for multi-channel objects (more than two channels), all combinations of physical and software simulations of the operation of the channels of the corresponding device are performed sequentially in time.
The main disadvantages of the separate channel method are:
- complexity of setting up the test complex;
- the highest degree of adjustment of technological applications of mid-level application software (ASW), which must be returned to their original state during normal operation of the system.
However, with strict adherence to the regulations for adjustments and changes, which must prescribed in programs and test methods, these shortcomings minimized.Based on the results of the study, it established that the time resource for restoring technological applications after testing with the most complex combination of methods of isolated objects and channels, taking into account the control check established by the author using the example of a system microprocessor centralization of switches and signals of railway stations MPC-S [3, 5], no more than four man-hours.
Similarly, access to connection points for drivers of interaction with real controllers and SIM software modules is organized for any number of groups of control systems for any number of channels of lower-level controllers with an arbitrary method of redundancy.
The implementation of the isolated object method allows for complete coverage of all technological situations for the test object, as well as the use of automated testing tools. At the same time, a complete check of the safety, reliability and performance of the system as a whole is ensured, with the maximum possible coverage of functions and conditions.

Conclusion

The main advantage of the isolated object method is that it corresponds to all the positive properties (characteristics) of testing methods on simulation models and bench tests with a minimum configuration of the test complex with lower-level software and hardware of the automated process control system under study and physical mock-ups of the control unit. Thus, all the shortcomings of simulation and bench tests are practically eliminated, as a result of which the reliability of the experimental results increases and the time and material costs for their implementation are reduced.
The main disadvantage of the isolated objects method is the relative complexity of setting up the test complex and the need for more significant adjustments to the technological applications of mid-level software.

References

[1] Glinkov, G.M. Process control system in ferrous metallurgy [Text] / G.M. Glinkov, V.A. Makovsky. – 2nd ed., revised additional – M.: Metallurgy, 1999. – 310 p.

[2] Dukhanov, A.V. Simulation modeling of complex systems: a course of lectures / A.V. Dukhanov, O.N. Medvedev. – Vladimir: Vladim Publishing House. State University, 2010. – 115 p.
[3] Kustov, V.F. Improvement of testing methods for microprocessor centralization for application safety / V.F. Kustov, A.Yu. Kamenev // Current issues in the development of railway automation and telemechanics systems: collection of scientific papers. – St. Petersburg: PGUPS, 2013. – P. 103 – 118.
[4] Mesarovich, M. Theory of hierarchical multi-level systems / M. Mesarovich, D. Mako, I. Takahara; lane from English; edited by I. F. Shakhnova; preface member-corr. USSR Academy of Sciences G. S. Pospelova. – M.: Mir, 1973. – 344 p.
[5] Patent No. 77047. Ukraine MPK G05B 23/00. Combined test complex for microprocessor centralization of arrows and signals / A.Yu. Kamenev, V.F. Kustov; applicant and copyright holder Ukrainian State Academy of Railway Transport. – No. U201208749; application 07/16/2012; publ. 01/25/2013, Bulletin. No. 2. – 6 p.
[6] Estublier, J. Impact of Software Engineering Research on the Practice of Software Configuration Management / J. Estublier, D. Leblang, A. Hoek and others // ACM Transactions on Software Engineering and Methodology. – 2005. – Vol. 14, No. 4. – Pages 1-48