REAL-TIME EXPERT SYSTEM FOR CONTROL OF ELECTROPHYSICAL COMPLEX

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Abstract

This work is the continuation of research in the field of a real-time expert system (RTES) prototype for control electrophysical complex (EC) [1,2]. The work was realized with the Gensym's G2 (USA), development environment for creating and deploying intelligent real-time application.

The main goal was the modernization of the previous RTES version by adding new subsystems in the scope of the existing features. This became possible thanks to the new technologies of dynamic expert system. In particular the problem-oriented G2-based product such as G2 Diagnostic Assistant (GDA) was used. It must be noticed that RTES is oriented to wide range of specialists in the EC's area. All of them have different experience not only with RTES but also with the G2 instrument. Therefore it was necessary to create a comfortable user interface (UI) and a visual model of the RTES prototype.

The architecture of the current version of the RTES prototype was widened at the expense of including new support subsystems such as: the provision of electrical energy, of water, tunnel ventilation, radiation protection, fire-prevention.

Furthermore an essential difference of the new version of RTES prototype was the possibility to quickly configure the EC subsystems. For these purposes a special mode of automatic generation of new EC subsystems configuration was designed in accordance with the designer's (or engineer's) requests (so-called the "master"). The "master" requested for a tool kit that allowed him to create any possible EC's configurations regardless the type and quantity of the used item. Another "master" request was the possibility of operation allowing to optimize the configuration of complex for different criterions.

The new prototype version of RTES for controlling the EC included the modeling of alarm situation. This system permits to similar extreme situation of the EC's process with links to the work damage of one or more EC's support subsystems. As a result it is possible to test reactions on emergency events of different EC's configurations as was created by the "master".

1 INTRODUCTION

Last years significant research and development in the field of dynamic intellectual systems, in particular real-time expert systems, for the decision of major strategic tasks has been observed all over the world. Examples are: management of complex systems and complexes in real time, monitoring and diagnostics of the status of technical objects in case of appearing danger, intellectual management of continuous productions, reengineering of the companies, organizations and other tasks.

The object of research in this work is the modern electrophysical complex. The complexity of EC consists in its large dimension, its non-linearity, its non-stationary nature as if requares the interconnection and management of subsystems of systems that are frequently adjusted. Therefore, as a rule, EC have a multilevel distributed control's architecture. The total number of parameters subject to control and management in real time, can reach several thousand.

During the last three years MEPhI has invested sighificant effort in the theory, the methodology and the technology of constructing dynamic RTES for diagnostics and management of modern EC. This work is based on the use of the G2 development environment to support the development of RTES. It is possible to find the detailed description of the architecture, composition structure and features of the basic components of the prototype RTES in works [1, 2, 3].

It is necessary to note, that EC includes some tens different subsystems providing data or the reception of charged particles, on their acceleration, then focusing and transportation at the certain requirements depending on the energy, power disorder, angular divergement and temporary characteristics of charged particle beams Proceeding next from the large complexity and multifunctionality of the developed system, the modular principle for creating prototype RTES for EC was used. At the initial stage of the creation of prototype RTES, three subsystems of life-support EC were used: maintenance of vacuum, cooling superconducting magnets and RF feed.

Currently the focus is on the further development and updating of the prototype RTES by expanding the simulated subsystems, increase the amount of undercontroled elements and expanding the circle of soluble tasks. In addition, as the architecture of the current version of the RTES prototype was considerably extended at the expense of the inclusion of new subsystems of life-support (see higher), problems have arisen with configuring the EC subsystems, their operative monitoring and with the forecasting of probable behaviour of the EC.

Various solutions for the construction of the RTES prototype for the EC controls is considered below.

2 THE BASIC PRINCIPLES OF CONSTRUCTION OF IMITATING MODELS FOR THE PROTOTYPE RTES FOR EC

The essential difference of the current version of the prototype RTES for EC is the use of the advanced imitating models (IM) of the life support subsystems' architecture. We shall consider the basic principles and methods of construction by using IM.

EC - complex system intended for a physical experiments that runs out many hours. The life time of a beam with a luminesity that allows to carry out experiments, should be of several tens hours. The vacuum in the main ring should be not worse than $2*10^{-9}$ mm Hg. This is reached, for example, by the use of turbomolecular and vacion pumps. The vacuum chamber is cooled by liquid nitrogen at a temperature of about 77K, that allows to remove heat emission from the drain current induced in the walls of the vacuum chamber by a circulating beam. The perimeter of the vacuum chamber of in the main ring of modern EC is of about 20 - 25 kms. Thus, for maintenance of so high vacuum in the chamber several tens vacuum pumps are installed. For circulation and dispersal of a beam of particles strong magnetic fields are used. For these purposes thousand of magnets are installed.

The task of the RTES consists in ensuring the control on top of the functions of these objects, and also to carry out diagnostics and to monitor both the subsystems and complex as a whole.

For the decision of the put task the following variants were chosen:

1. stage 1 - visualization by IM of the life –support subsystems and of their interaction,
2. stages 2 - analysis and design of possible variants of the decisions the put problem with use of IM,
3. stages 3 - implement of the produced design decisions on the real EC.

The realization of first two stages enables already to use the prototype RTES for the decision of such tasks[1], as

a) Schematic performance of the basic processes proceeding at functioning of a complex in its various subsystems and at different levels of detailed elaboration of subsystems and processes;
b) Graphic user interface for the control and supervision of the changes of the basic parameters describing activation of a complex (management, monitoring);
c) Automatic control of the functioning of the complex and of the control system; registration of deviations from the nominal or from the given mode and notification of the operators, signaling emergency situations and their reasons, adjusting a mode of operation and emergency disconnect, returning a complex in a working mode taking into considiration operator's advice;
d) Study of the operators action on the management of a complex and training of the personnel (work in a mode "simulation");
e) Realization of the archiving of all actions of the operators and current parameters of a complex with processing of the information on the given and set algorithms and distribution of the necessary information on searches (such a statistical data used for the diagnostics).

The use of G2 for the development of the prototype RTES provides an object-guided paradigm for designing the system by IM. This way the program object is put in conformity to each element of the equipment and the physical interaction between the equipment is entered as a relation between the corresponding objects.

Initially the class of certain equipment is described: the classname (for example, NEM-300, that meets to the equipment such as vacion pumps), property (for example, weight of an element, capacity, resource etc.), and finally the methods or probable functional actions of objects (for example, mode "winking" for an emergency lamp).

Thus G2 gives to the developers all characteristics of the object-guided approach such as: encapsulation, multiple inheritance, polymorphism. After the description of a class, there is an opportunity to create a copy of the given class (object), to place it in the necessary place and to connect (to set necessary attitude[2]) it with other objects of model. Thus, sets of cooperating objects and then fundamental physical laws form the basis to model a complex. The basic complexity when constructing EC life-support subsystems by IM, arises when imitating its

[1] Taking into account opportunities chosen development environment G2 (GSI, JavaLink), all below listed opportunities of the prototype RTES are possible for transferring on a really working complex (stage 3).

[2] At the description of actions and interactions of objects in IM it is necessary to take into account of the fundamental physical laws: the law of preservation of weight, law of preservation of energy, law of preservation of a pulse, gas laws, equation of a status.

continuous physical process in system G2, in particular its functioning in soft real time (time of reaction about 0,5 s). Experiments have shown even for a subsystem of maintenance of vacuum, such time of reaction it is enough for correct functioning of the prototype (the diagrams of pumping were compared).

3 MANAGEMENT, MONITORING AND DIAGNOSTICS IN THE PROTOTYPE RTES

Design and development with IM (stage 1) gives the opportunity to choose the most suitable algorithms for the central control and to integrate them in the IM (transition to stage 2).

The basic idea of management in the IM consists in the formation of a vector of managing influence

A = {aij} (i = 1..., n, j = 1..., m, and aij = 0, 1), where

n - quantity of elements under control in a subsystem,

m - quantity of possible functional actions of the appropriate element,

the value aij = 1 means the need to include action (j) of object (i) aij = 0 means the opposite.

Such vector is formed so as to describe the scales of a subsystem of a complex (for example, maintenance of vacuum), and as well as in view of a status of the overall complex.

Finally, the expert knowledge and previous experience with a given class of systems (EC), is transferred in the knowledge base as rules, with the help of IM.

4 TECHNICAL CHARACTERISTICS

The following ways are possible for perfoming stage 3: GSI, JavaLink (complete crossplatform application), ActiveXLink or CORBALink.

The group work can be supported by interfaces G2↔G2, G2↔Telewindows, G2↔Telewindows2 (Internet of technology).

The application functions on a Windows NT4 platform, equiped with the Intel Pentium II 350 processor and 128M of operative memory. The interface trunk to external devices is RS485.

5 THE CONCLUSION

The current version of the prototype RTES functions with the use of “imitating models” of the architecture of life-support subsystems. It provides : the opportunity to vary the amount of the same elements, as will be determined by the developer with the help of "foreman"; the laws of interaction of various subsystems; to model both the methods of monitoring and diagnostics of the overall EC. Testing the prototype RTES, including the models of all basic EC life-support subsystems, component "monitor" for supervision over a status EC, and also development of specialized software for forecasting extreme situations of subsystems.

This will supply further opportunites to replace a source and a receiver of concrete gauges data and other real equipment data. It will also expand the means of program management of a complex, of reception and processing of the necessary data, of monitoring and forecasting the probable statuses of a functioring EC etc. It is necessary also to add, that the interaction of the prototype RTES with external devices EC is under construction on the basis of GSI.

REFERENCES

[1] V.M. Rybin, G.V. Rybina, A.E. Haritonov, “The Matters of Use G2 Instrument for Prototype Creation of Real Time Expert System for Control of Electrophysical Complex”, in Proceeding KAI-96 Five national conference with international participation " Artificial Intelligent - 96 " (Kazan, 5-12 of October 1996) The scientific labours collection in 3 volumes. Vol. 2. M. AAI, 1996, p.225-230

[2] G.V. Rybina, V.M. Rybin, “Using the Tools Complex G2 for Control of Electrophysicl Complex. Accelerator and Large Experimental Physics Control Systems”, in Proceeding of the 1997 International Conference on Accelerator and Large Experimental Physics Control Systems (Beijing, China, November 3-7, 1997). Editors J.Zhaanel A.Daneels. Science Press. Cern, Switzerland, 1998, p. 107-109

[3] G.V. Rybina, V.M. Rybin, “G2 Real-Time Expert System for Control of Electrophysical Complex”, in Proceedings 2nd IMACS International Multiconference CESA ' 98. Computational Engineering in Systems Applications. Nabeul-Hammamet, Tunisia, April 1-4, 1998. Vol.1, p. 659-663