DYNAMIC INTEGRATED EXPERT SYSTEMS: THE EVOLUTION OF AT-TECHNOLOGY WORKBENCH

Galina Rybina, Victor Rybin

***Abstract**: The current state and trends in the area of dynamic intelligent systems are analyzed. The first experimental results obtained in the development of certain provisions and components of the task-oriented methodology for the integrated expert systems construction during the transition to unformalized problems in dynamic areas of concern solving are considered. State and tendencies of evolution of modern development tools for static and dynamic expert systems development are being analyzed. New facilities of unique Russian instruments for support of integrated expert systems development – the AT-TECHNOLOGY workbench – connected with dynamic integrated expert systems development are in question.*

***Keywords**: dynamic intelligent system, dynamic integrated expert systems, task-oriented methodology, AT-TECHNOLOGY workbench, development tools real time, simulation modeling, temporal reasoning, temporal reasoner.*

***ACM Classification Keywords**: I.2.1 Applications and Expert Systems; I.2.5 Programming Languages and Software*

Introduction

In the context of the analysis of trends in modern tools for intelligent systems development in general, it should be noted that at present the highest growth rates are observed in the area of development tools (DT) for support the development of static and dynamic expert systems.

As it was shown in [1], this is due, primarily, that the scientific and commercial progress in the development of static expert systems (ESs) in the mid-80's and integrated expert systems (IESs) in the late 90's, led to increasing demand and expansion of industrial use and development of applied ESs and IESs for a wide class of problems of real practical importance and complexity, including the dynamic areas of concern (AoCs).

To these dynamic IESs, which function, as a rule, in real time (IESs RT), there are imposed some new requirements such as [1]: performance, storage and analysis of time-varying data from external sources, the implementation of concurrent temporal reasoning about multiple asynchronous processes (tasks), including those with limited resources (time, memory), the possibility of modeling the external world and its various states, etc. That’s why in the architecture of any IES RT (compared with static ES) there are included some special components that simulate the external environment and allow to interact with hardware in real time. It significantly complicates the process of developing such systems and requires highly skilled developers and experts [1, 2]. So a robust DT, providing the development of the dynamic ESs and IESs, capable to operate in dynamic AoCs with possible adjustments in strategies for reasoning and updating the knowledge base directly in a process of reasoning are needed.

In [1, 2, 3] there is presented the most complete overview of domestic developments related to the creation of dynamic IESs for electro-physical complex management, diagnostics of complex technical systems, prelaunch launch vehicles control, radio-ecological monitoring of areas adjacent to the nuclear power plants, atmosphere air monitoring, forecasting of on-board micro-computers radiation damage, etc. Description of some foreign dynamic ESs to control a continuous production process in chemistry, pharmacy, production of cement, food products, aerospace research, transportation and processing of oil and gas, management of nuclear and thermal power plants, finance operations, etc. is given in [2, 4].

Analyzing the success of Russian scientific schools in the area of dynamic intelligent systems, it should be noted diverse range of theoretical and methodological research related to the creation of the theory of constructing a specific class of dynamic intelligent systems based on the rules [5], the results obtained in simulation of time (temporal) reasoning for intelligent decision support systems for real-time [6], the cycle of research and development in the field of dynamic systems under the guidance [7], as well as a number of other interesting theoretical works [8, 9]. However, in general, the problem of creating powerful software tools to support the development of dynamic intelligent systems, in particular the dynamic ESs and IESs, practically, hasn't been intended.

A new research project related to the development of the instrumental base of the AT-TECHNOLOGY workbench to the level of the modern DT for support the development of Dynamic IESs is in question of this paper.

Evolution features of instrumental base for dynamic expert systems at the turn of XX-XXI centuries

One of the first foreign tools for dynamic ESs development, which was intended for character computer Symbolics and was named Picon, was created by Lisp Machine Inc (USA) in 1985. The success of Picon led to that group of leading developers had founded a company Gensym and released DT G2 based on evolution of ideas used in Picon in 1988. Today the world is widely using version 8.3 of G2, and a number of problem-oriented DT, based at the G2 core for developing applications for special AoCs and special classes of problems [10, 11].

2-3 years after Gensym Corp. some other companies begun to create their own DT, the most famous of which are: RT Works (Talarian, USA), COMDALE/C (Comdale Techn., Canada), COGSYS (SC, USA), ILOG Rules (ILOG, France). According to the data given in [2,4], the objective comparison of the two most advanced systems - G2 and RT Works, which took place through the development of the same application by two organizations - NASA (USA) and Storm Integration (USA), showed a significant superiority of G2 (Gensym Corp.).

In general we can say that today in the field of instrumental base for support the development of dynamic ESs and IESs there is not such a great diversity, such as for static ESs, where there are hundreds of DT for different applications, with different power and cost (from several hundred dollars to several tens of thousands of dollars). Comparative analysis of foreign commercial DT for dynamic ESs [2], as well as experience of prototyping Dynamic IESs [2, 12], accumulated in the laboratory of Intelligent Systems and Technologies of Department of Cybernetics of National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), has shown significant advantages of G2 over other commercial DT of this class (RTWorks, R * Time, L * Star, TCD Expert, etc.), features of which do not exceed 50% of G2 features.

The high complexity and the difficulty of DT for the ESs and IESs development, the lack of funding and legal basis for protecting intellectual property rights are serious impediments to the creation of Russian DT appropriating to the level of G2 (Gensym Corp.). Significantly reducing or even exceeding the far gap between world and Russian level of solving tasks of such complexity and importance can be overcame by using the experience of developing and using powerful tools to build static IESs - a third generation of the AT-TECHNOLOGY workbench [1].

Some information about the AT-TECHNOLOGY workbench

Since the mid 90's in the laboratory of Intelligent Systems and Technologies of Department of Cybernetics of NRNU MEPhI research and development has been conducting, within which was created a new generation of DT

– complex AT-TECHNOLOGY for the automated development of software of IESs - one of the most complex class of intelligent systems, theory and technology of construction of which are described in detail in [1]. The instrumental software the AT-TECHNOLOGY workbench, transformed during this period to several technology generations of WorkBench type (i.e., integrated environment that includes tools of various levels of complexity, the selection administration of which is implemented by system as well as by knowledge engineers), supports the original task-oriented methodology proposed by G. Rybina [1].

This toolkit is a coherent set of tools for computer aided Design of IESs at all stages of the life cycle, also providing elements of "intellectualization" of the process of developing applied IESs based on knowledge about typical design procedures for the development of systems and their components for specific classes of problems and AoCs. Today the AT-TECHNOLOGY workbench is a powerful workstations for knowledge engineers, as well as undergraduate and postgraduate students studying the theory and technology of IESs construction. Since 1995 the complex has been used in the educational process of NRNU MEPhI and other universities.

More information about basic features and architecture of the AT-TECHNOLOGY workbench (including base and web-oriented version) can be found in [1, 13 - 17].

The evolution of instrumental base of the AT-TECHNOLOGY workbench for dynamic IES development

Long-term experience of using of the AT-TECHNOLOGY workbench for support of development of IESs on the basis of the task-oriented methodology [1] has shown that the class of problems where AoC is dynamic meets often enough. Therefore a cycle of researches directed on development of functionality of a the AT-TECHNOLOGY workbench (base and web versions) for supporting of development of dynamic ESs with scaled architecture, i.e. IESs, functioning in real time, began some years ago [1, 13].

In developing of IES RT as well as any other dynamic system, it is necessary to consider behavior of system in time i.e. to establish interrelation between parameters during the different moments of time, therefore as shown in [1, 13, 17], the integral stage of IES RT development is the test of components of created system with simulation model (SM) that provides possibility of an estimation of working capacity of dynamic IES, without expensive introduction of system. Methods and the means of simulation modeling focused on the description of a concrete class of SM are most often applied to modeling of conditions of complex discrete systems.

From a position of the task-oriented methodology and the toolkit supporting it − a the AT-TECHNOLOGY workbench, the greatest interest is represented by problems of integration traditional ESs with SM in architectures of the applied Dynamic IESs constructed on principles of deep integration of components [1], because in this case conceptual unity of all used approaches, models and methods as during development of AoC model and environment model, and in the course of searching of the decisions received in the conditions of temporary restrictions and other is provided.

As simulation modeling is the widest applied approach of modeling behavior of various systems in time now there is variety domestic and foreign DT, allowing to develop and make experiments on SMs, however the greatest attention, proceeding from the purposes of the given work, the concept of the environment of the imitating modeling RAO [18] intended for development and debugging of SMs in RAO language [18], having unlike other similar systems the most developed theoretical base. Certainly, it is not provided the full requirements of deep integration of components ES and SM in any system, nevertheless, using and development of the RAO-method, realizing the task-oriented approach to construction of SMs, is represented justified and expedient regarding development of architecture of a the AT-TECHNOLOGY workbench by the subsystem of simulation modeling of an external environment. Therefore on the basis of the analysis of base principles of construction of corresponding components of systems G2, RAO, etc. in the case of development of functionality of a the AT-TECHNOLOGY workbench for support of construction IESs RT, the tools providing construction of SMs of complex discrete systems and making experiments on these models have been realized first of all.

In the architecture of a prototype of a subsystem of simulation modeling [13] functionality of the developed tools is divided between two global modules - the module of development of SM, which provides development support out and debugging of SM and other functions demanding the visual interface, and the module of calculation of SM, which provides methods for calculation of conditions SM in each step of discrete time during imitational experiment. The module of development of SM comprises a number of the components providing various aspects of construction and using of model, namely:

- The models manager, which provides version control of developed SM and allowing to create new model on the basis of existing, to store various sets of models in the form of treelike structure;
- The models editor, which intended for construction of SM by the visual editor tools, allowing to create objects, setting their properties and attributes, and also to establish the connection between objects of model in a graphic mode;
- The component of visualization allows to draw animation shots and moving between them, and each shot of animation corresponds to a condition of SM on a certain step of discrete time;
- The analysis component, which supports the analysis of results of experiments on SM (reviewing of detailed reports of experiments, and also the various reports constructed by results of experiment that allows not only to draw a conclusion on success of experiment but also to reveal lacks of modeled system);
- The module of calculation of SM contains some components which provides different aspects of calculation of conditions of model, namely;
- Component of calculation of conditions of SM, counting a new condition of model in a certain step of discrete time on the basis of a model condition on the previous step of time taking into account the carried out operations initiated by IES or other operations of model;
- Component of generation of the probabilistic events, which realizes mechanism simulating random indignations in modeled system (the given mechanism initiates performance of certain operations of SM during the random moments of discrete time according to the law of distribution of probabilistic variables);
- The component of trace, which provides gathering statisticians and other necessary information on a condition of SM on each step of discrete time for the purpose of subsequent using by a component of the analysis of results for constructing various reports and schedules by results of experiment.

In the context of integration of tools for development of SM with corresponding components of base version of the AT-TECHNOLOGY workbench two main problems. Their decisions will allow integrating tools for development of SM into structure of the AT-TECHNOLOGY workbench.

The first problem is reduced to interaction maintenance between universal AT-REASONER of the complex [1, 13] and a subsystem of simulation modeling so that in the course of making reasoning, AT-REASONER could initiate actions (operation) over SM, which changes a condition of model for a certain interval of discrete time. Current version of the AT-REASONER provides a wide spectrum of functionality, which, in particular, can make calls of functions of special components, using COM-technology. It allows developing the interaction mechanism between AT-REASONER and a subsystem of simulation modeling, having realized the necessary interface.

The second problem is a sharing of working memory by a subsystem of imitational modeling and other components of the AT-TECHNOLOGY workbench that is possible by development of a special component - a gateway which synchronizes conditions of working memory of IES RT and conditions of SM into each step of discrete time during carrying out of experiment with SM. The basic functions of the given component are:

- Maintenance of the unified program interface, allowing to change a condition of working memory of IES RT by the subsystem of simulation modeling;
- Scanning of working memory in each step of discrete time and transferring information about the changes brought in working memory by components of the AT-TECHNOLOGY workbench to a subsystem of simulation modeling.

Integration of the developed tools for development of the SMs with base subsystems of a the AT-TECHNOLOGY workbench is rather not trivial problem, therefore for these purposes the special program stand has been created. It provides carrying out of debugging of integration mechanisms of various components of the complex [8].

Researches, that has been made at the program stand, has shown possibility in a mode of real time to transfer data about changes of the conditions of SM in working memory of the AT-REASONER, and also to receive and execute influences on the model, initiated by the AT-REASONER during the reasoning.

Therefore a following important stage of development of the AT-TECHNOLOGY workbench for support of the Dynamic IESs development is an expansion of possibilities of the AT-REASONER to make temporal reasoning which is connected with creation of special temporal reasoner. In the results of comparison of various models of time representation by several criteria the model of Allen's interval time logic [19] has been chosen (due to its possessing balanced enough characteristics by all criteria and having the developed mathematical methods). The preliminary experimental researches connected with modeling of architecture of a prototype of the temporal reasoner using of G2 system, have shown efficiency of application of Allen's interval logic proceeding from the purposes of the given work.

More information about temporal reasoning implementation in AT-TECHNOLOGY workbench can be found in [17, 19 - 28].

Conclusion

Further evolution of the AT-TECHNOLOGY workbench tools to support development of Dynamic IESs (so-called "dynamic version") involves the empowerment of the AT-REASONER for the implementation of temporal reasoning [17, 28], the development of tools to get data from external sources in real time, and implementation of other mechanisms for constructing Dynamic IESs within the confines of the task-oriented methodology.

Acknowledgements

This work was supported in part by the Russian Foundation for Basic Research under Grant No. 12-01-00467.

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