Continuous Acquisition and Life-Cycle Support (CALS) Simulation Models on the Basis of the ERP and CAD Technologies Integration

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Abstract In present article an intellectual data analysis and simulation modeling methods were used for management of information flows of manufacturing enterprise on the basis of ERP (Enterprise Resource Planning) and CAD (Computer-aided design) systems. CALS-simulation model on the basis of Petri nets as an integration tool of the industrial automated systems in a uniform multifunctional business processes control system is designed. Data mining methods development for effective support of decision-making of steady meta-structures of logical data patterns identification are also investigated. The conceptual scheme of evolutionary modeling methods integration for intellectual data analysis of business processes management is developed.

Keywords ERP • CALS • CAD • Data mining • Petri nets • Decision support system (DSS)

1 Introduction

Nowadays, modern enterprises are faced a problem of a reliable control over a high volume of diverse data stored and used in the various information systems for information support of products during their life cycle.

The main purpose of research is creation of effective models simulation of business processes management in the conditions of uncertainty. Existence of uncertainty complicates the forecast of information flows stability and makes it impossible to create models on the basis of analytical expressions. Therefore intellectual data analysis methods application and CALS (Continuous Acquisition

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and Life-cycle Support)-technologies for an assessment of efficiency of ERP modules integration with external systems, on the example of CAD is expedient [1].

ERP (Enterprise Resources Planning) built on the basis of CALS technology help to solve this problem [2].

CALS technologies serve as integration tool of industrial multi-functional system. The purpose of integration of the automated systems of design and management is improvement of efficiency of design and usage of the complicated industrial systems by means of their effective interaction [3].

Key component of information integration is the PDM (Product Data Management) system—technology of management of complete product lifecycle data.

The main objective of PDM-technology is making information processes more transparent and controllable. The main method applied is increase of availability of data for all participants of product lifecycle. It requires integration of product's data in logically uniform information model.

The simulation modelling method is an essential part of automation allowing improvement of design and research of complex systems.

2 Simulation Model Design

The typical CAD architecture separately allocates the simulation block from other functional parts. Peculiarity of applied systems like CAD is integrity of design technology and the automated system:

– Methods and techniques used in the design organization influence on methods realized CAD;
– CAD functionality influences methods which are used by the design organization.

Introduction of simulation block into structure of CAD allows passing to new qualitative level of design. Quality of design is reached at the expense of possibility of more complex challenges solution and at the expense of increase in extent of same type design decisions making. At increase in power of a set of considered alternatives the engineer can use an identical technique [4]. Therefore he can apply the same technique. Extent of processes proceeding typing at design influences the cost of all process of development. According to the experts design cost owing to typing of the project can decrease by 3.3 times.

The constant increase in arrays of processed information results in need of processes intellectualization of the automated industrial design, thus one of the central tasks is creation of effective solution of problems of intellectual knowledge extraction. The problem of uncertainty is a component of a problem of complex systems solution state identification and forecasting. The model of complex system can't be based on the principles of the analysis as it will be inadequate to studied system as at division of system into compound components its certain properties are lost. Therefore detection of the hidden regularities between variables characterizing behavior of studied dynamic systems is an actual problem of the intellectual data analysis. Integration of the existing Data mining methods (DM) and Deep data mining (DDM) with the newest perspective directions of development of evolutionary modeling methods will allow to increase efficiency of procedures of forecasting, classification, clustering, association and other types of logical regularities in data.

3 Main Problems and Directions of Their Decision

Researches in the field of knowledge extraction are directed on the solution of information intellectual systems fundamental problems:

– Ranging, segmentation, forecasting, identification and identification of associations and exceptions in studied factors of complex dynamic systems design
– Developing the principles of the intellectual data analysis (Data mining), connected with carrying out complex theoretical researches in the field of evolutionary modelling

The problem of creation of theoretical models, methods and algorithms of the intellectual data analysis in the conditions of uncertainty, on the basis of integration of methods of evolutionary modelling, makes the important direction of researches within the specified problem.

Development and research of the fundamental principles of application of neural network technologies are also necessary for creation of new algorithms of definition of the main types of regularities in Data mining [5]. A certain attention should be paid to modernization and integration of means of increase of reasoning systems efficiency and subject-oriented analytical systems on the basis of genetic algorithms application and artificial neural networks. Important research problem is possibility of new technologies development of metastructures identification of logical regularities in data.

4 Development of Knowledge Discovery Methods in Conditions of Uncertainty

Development of the theory and the principles of creation of intellectual knowledge discovery in databases (KDD) in uncertain conditions have to be carried out on the basis of a combination of self-learning, self-organization, genetic search and neural networks that will allow to break a barrier of a local optimum. Application of evolutionary modelling technologies and artificial intelligence will allow increasing efficiency of search of useful information in a priori data. Optimization of data preparation procedures, choice of informative attributes and data cleaning will allow improving and accelerating processes of the further analysis by Data mining methods.

The conceptual solution scheme of the considered problems is development of the new principles of multidimensional extrapolation of conditions of complex dynamic systems can be carried out on the basis of strategy of the combined search of logical regularities of studied factors—combinations of different types of neural networks and genetic search.

The greatest interest is represented by development of new methods of forecasting on the basis of integration of properties of prototypes development by dynamic and complex neural networks. As well as methods of parameters forecasting of a condition of object generalization on prevalence and similarity with use of case based reasoning (CBR) models with expanded functionality in the direction of creation of models and the rules generalizing the previous experience. For this purpose it is possible to carry out integration of reasoning systems with the problem-oriented analytical systems (POAS), since the first—effectively predict behavior of dynamic systems on the basis of analogies, but don't create models, and the second—on the opposite, have the necessary device of empirical modelling.

Expediency of use of neural network systems for forecasting of properties of such objects is caused by specific properties of the neural networks (NN):

- Ability of the operational multiple parameter analysis;
- Tolerance to a lack of aprioristic information on predicted object dynamics;
- Possibility of the data processing, presented in different types of scales;
- Ability of identification of implicit analogies of precedents of the supervision protocol;
- Preservation of the properties at destruction of casually chosen part of neural network, that causes high reliability of a network;
- Ability to self-learn;
- Possibility of the events forecasting that weren't observed earlier in learning selection.

Neural networks properties are defined by its architecture, and also set of synaptic connections and neurons characteristics. Predictive neural network model has to be capable not only continuously process a large number of parameters of system, factors of an expected background, but also to consider diverse information on current and planned modes of object functioning [6]. The neural network system of forecasting, in turn, has to consider information on system work logic, reliability of its elements, as well as expert information.

Dynamic neural networks have opportunities for modelling of intellectual functions. Recognition systems on the basis of static neural networks are capable to approximate complex dividing surfaces in attribute space and to distinguish the hidden dependences.

Thus, at the heart of a neural network method of expeditious forecasting for formation of a prototype it is necessary to use abilities of complex neural networks, as the main instrument of extrapolation in attributes space not observed before a situation.

The main lack of multilayered neural networks that is seriously limiting their practical application is slow convergence [7]. For convergence acceleration it is necessary besides development of effective algorithms of the return distribution, embedding in a structure knowledge network of research object and preliminary learning to apply hybrid networks in which neural networks contact the structures of received forecasting on the basis of other technologies, i.e. conclusions are drawn on the basis of other evolutionary methods, and the membership functions of accessory are arranged with use of neural networks learning algorithms [8].

One of the perspective directions of development of similar systems is inclusion of the genetic algorithms (GA) in process of neural networks learning [9]. GA is used as procedure for network learning since application of back propagation algorithm significantly complicates learning procedure. Moreover, GA allows adjusting a neuro-controller when giving on its input the output coordinate of an object on the current and previous steps [10]. The combination of two perspective computing technologies—genetic algorithms and artificial neural networks—allows solving effectively a problem of forecasting of dynamic system behavior within an evolutionary paradigm.

Having generalized all offered principles of the intellectual data analysis methods development, it is possible to offer the following decision-making support system structure on a basis of Data mining technologies (Fig. 1).

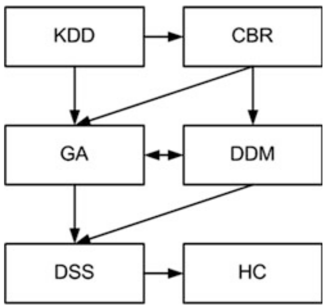
Use of simulation modelling allows examination process simplifying of the received CAD decisions. Transparency of examination allows involving investors in project financing that in conditions when the project cost of design can reach hundreds and thousand dollars is a necessary condition of implementation of the project [11]. Besides, use of the simulation module in the course of carrying out examination of projects reduces examination time.

At simulation modelling of complex dynamic systems on the basis of Petri's nets set entrance flows of demands and define the corresponding system reaction. Output parameters calculated by processing of the statistics saved up at modelling [12].

Other approach of Petri's networks usage for the analysis of complex systems is also possible. It isn't connected with processes simulation and based on research of such properties of Petri's networks, as boundary, safe, terminal, live.

Simulating in Petri's networks is carried out at event level. Performance of event model in Petri's networks describes system behavior. Performance results analysis

Fig. 1 Decision-making support system structure



can tell what conditions the system stayed or didn't stay and what conditions aren't achievable [13].

Petri's network is represented as four <P, T, I, O>; where P and T—final sets of places and transitions, I and O—sets of input and output functions. In other words Petri net is directed bipartite graph in which the places—nodes signified by circles, and transitions, signified by bars; I functions—arc directed from places to transitions, and functions O—the arches directed from transitions to places [14].

As well as in systems of mass service, in Petri nets objects of two types are entered: dynamic which are represented by tokens (markers) in places, and static which nodes of Petri net correspond [15].

Distribution of markers on places called marking. Markers can move to networks. Each change of marking call an event, and each event is connected with a certain transition. It is considered that events occur instantly and asynchronously when performing some conditions.

To each condition in Petri net a certain place corresponds. Commit event corresponds operation (excitement or start) transition, in which markers from input positions of the markers in the input of this transition are moved to output positions. The sequence of events forms modelled process.

As an example, we will construct by means of Petri net the integrated simulation model of system functioning at integration level of design in CAD (Fig. 2).

Process of design begins with specification (S) discussion by interested persons of P1 and P2, in these places there are markers. According to rules of operation of transition to Petri nets, there is an operation of transition of T1. As a result, markers from positions of P1 and P2 passes to the following position P3, there is a specification on product design.

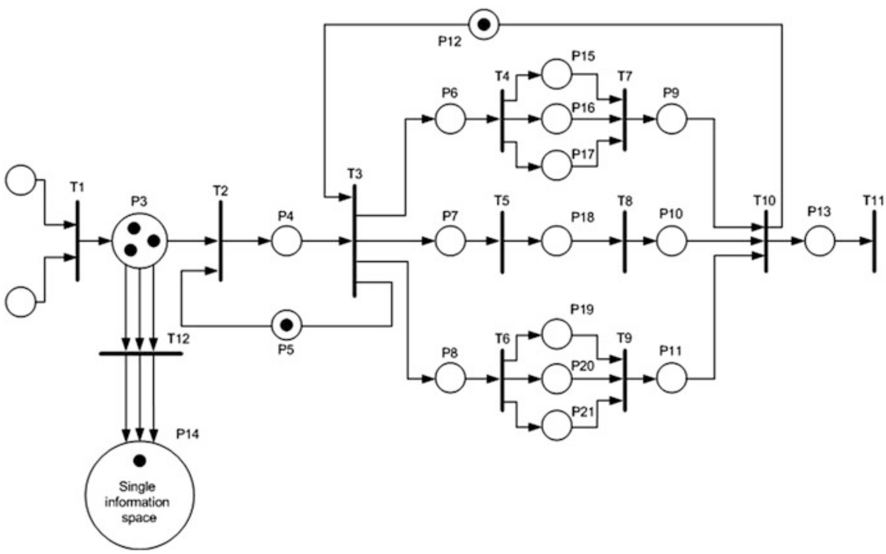


Fig. 2 CALS-simulation model

In Petri net there is such parameter as limitation (or K-limitation) if the number of tags in any position of a network can't exceed life-cycle's value design of the automated systems definition Limitation of all positions is equal in this network K1, except a position P3 in which this parameter is equal 3. Necessary data accumulates in a place P3 which in this case is PDM system distributing and operating data. Transition of T12 to a position P14 works if the quantity of markers in a place P3 reached maximum and T2 transition is closed. The place P14 imitates possibilities of the uniform information space (UIS) of the enterprise and markers (S) arrive on processing in similar divisions of design. Transition of T2 works in the presence of a marker in a place P5, showing that the place P4, is free for acceptance of a marker of S from a place P3. The place P4 is the beginning of process of system integration design. Transition of T3 works if in a place P12 there is a marker regulating load of this department by design work.

Places P6, P7, P8—indicate the main directions of conducted researches:

P6—define computer architecture
P15—functions identification
P16—functions division on hardware and software
P17—list of commands determination
P7—block diagram development
P18—quality options assessment
P8—modules requirements specification
P19—modules functions definition
P20—data format development
P21—base elements items

Transitions of T4, T5, T6 work when in places P6, P7, P8 there are markers of continuation of design process. Transitions of T7, T8, T9 work when markers are in the previous places. In each position of process of design temporary delays connected with need of the synchronization of data transmission are possible. In Petri's networks it is described as model time, to model not only sequence of events, but also their binding at the right time. Transition of T10 is the end of integration system design. It works at the moment when in all places P9, P10, P11 markers that testify the end of development task appear. At operation of this transition the marker passes to places: P12, P13 meaning readiness for a new cycle of integration system design. Further, works T11 transition, then developed specification (S) arrives in PDM system.

Processes management functions in PDM-system are intended for control ways of data change and creation. Process management concerns a product life-cycle support procedures and their influence on product data. It is possible to distinguish three main groups from its functions:

1. Work management (consider what happens to data when someone works over them).
2. Work flow management (operate data exchange).

3. Work logging (trace all events and actions, which occur when performing the first two groups of functions during all history of the project).

5 Conclusions

CALS-technologies can effectively manage information flows, creating and using a single information space. Major barrier to the widespread use of this approach in CAD and ERP is the problem of ever-increasing amounts of data being analyzed. Integration of CALS-technologies and data mining approaches will greatly improve multipurpose decision support systems (DSS).

The direction of evolutionary modeling applications for creation of new theoretical provisions, methods and algorithms of definition of a number of the main types of regularities of Data mining—classification, a clustering, association and sequence in the conditions of selections, insufficient aprioristic information on correlations between studied factors, nonlinear dependences, noisy and incomplete data is perspective.

For the purpose of efficiency increase of evolutionary search process it is necessary to develop and theoretically prove model of integration of subject-oriented analytical systems and genetic algorithms, for the purpose of an exception of unproductive branches of evolution. The subsequent inspection of the received models on adequacy can be made by development of multilevel neural network architecture of received systems models test.

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