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DYNAMIC DATA INTEGRATION IN THE DESIGN OF COMPLEX COMPUTER-AIDED DESIGN SYSTEMS

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Abstract**—***Presented computer-aided design with an integrated environment introduces a new approach to managing the design process. Used in the proposed medium scenario design can greatly simplify the work of the designer. Available in medium monitor provides the flexibility of design processes with a flexible structure description of design procedures in the scenario design.*

Index Terms—Dynamic integration; computer-aided design; integrated environment.

I. INTRODUCTION

Computer is an aided design (CAD) system (automated system that realizes the information technology performing of the design functions [1].

Using CAD allows to solve the following economic and industrial problems:

– expansion of functional possibilities of manufactured products;

– improvement of reliability and accuracy;

– optimization of manufactured cost;

– fighting for the buyer;

– acceleration of manufactured cycle.

In the life cycle of manufactured products CAD solves the problem of automating during the design and manufacture preparation.

The main CAD's objective is to improve the efficiency of engineers, including:

– reducing the complexity of the design and planning;

– reduction of the design;

– reducing the cost of designing and manufacturing, reduction in operating costs;

– improving the quality and feasibility level design results;

– reducing the cost of natural modeling and testing.

Structurally CAD consists of the following modules [1].

1. Design of mechanical components and their interaction:

– design of the general form of the product;

– design of construction;

– calculation of strength of all parts and components;

– kinematic calculation.

2. Design of electrical circuits:

– development of electrical circuits, printed circuit boards, the choice of electronic components;

– development of simulation modeling system;

– development of creation technical documentation system.

II. PROBLEM STATEMENT

To date, there are dozens of software products intended for the solution of every problem of computer-aided design (Compass-3D, Altium Designer, MatLab, Catia, Solidwork, DIALux, Anfys, Flowvision etc.). But these software products in general are not universal. So, it's necessary to develop a new CAD system for the design of every separate product. From an economic point of view it isn't profitable. So it's expedient to look for the way which will permit to combine existing software products in an integrated CAD system for the design of given plant.

III. METHOD OF THE SOLUTION

To achieve this goal it is necessary to solve the following problems.

1. To choose N software products (W_1, W_2, W_3, ..., W_N), combined use of which can solve the problem of given plant CAD.

2. To develop the methodology of integrated CAD creation based on redirecting of information flows.

3. To realize the data integration in a single information process.

The first stage is unique for each separate task and depends on the capabilities and preferences of the customer, hence, there is no optimal algorithm for solution of this problem. Here an individual approach is used.

IV. REVIEW OF INTEGRATED CAD SYSTEMS DESIGN METHODS

It's possible to distinguish two fundamental approaches of integrated CAD systems design in terms of information flows [2]:

– integration "everyone with everyone";

– integration using the integrating module.

Integration of "everyone with everyone"

It is a traditional approach for systems integration, which it is concluded in the creation of specialized data communication interfaces for each pair of communicating applications (Fig. 1).

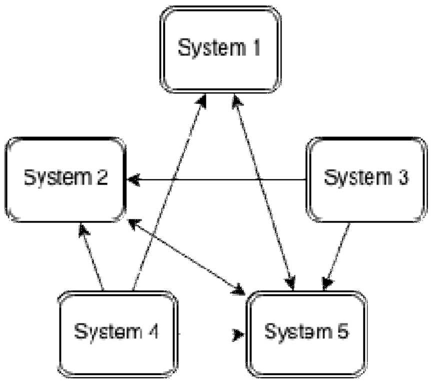

Fig. 1. Integration of “everyone with everyone”

This approach is good for limited number of applications. When their number is large, the it does not work practically. Furthermore, it does not allow to form the qualitatively new requests to the combined data, i.e. a qualitative win from the combining of the data is absent [2].

Using this approach, we have N systems, as far as each system has a connection with some systems (from 1 to N – 1), then for the whole system it is necessary to create from N to $N(N-1)/2$ pairs of data transformations “$W_i – W_j$”, and / or “$W_j – W_i$”

Integration using the integrating module (Application Service Bus).

This approach implies the existence of a link unit between all the modules via Application Service Bus (ASB). It manages all available system modules and is responsible for the interaction between the modules, data conversion (if needed), and performed work quality control (Fig. 2).

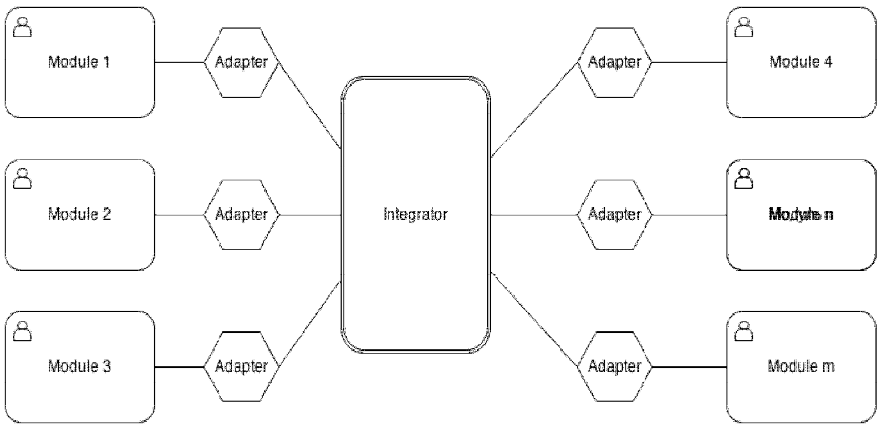

Fig. 2. Integration using the integrating module

Using this approach minimizes the cost of adding new modules and upgrades of current, reduces maintenance costs of the system as a whole, and simplifies the management of data flows in the system [3].

Typical problem of integration is the interaction of two or more application systems through the exchange of data. Required components for integration are:

– adapters applied to ASB systems for sending and receiving messages;

– Application Service Bus, which should consist of at least: transport system and conversion of data format messages;

– routing (content) messages between application systems.

When using the Service Bus Applications we have N systems because each system is connected only to the Integrator, then it is necessary that the whole system to create N pairs of data transformations of form “W_i-Integrator”, “Integrator-W_i”.

The advantages of this approach are obvious, but it requires the creation of an intermediate format, which should be strictly standardized (Fig. 3).

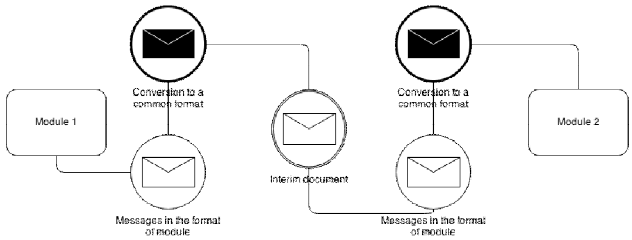

Fig. 3. Format conversion mechanism

V. DYNAMIC DATA INTEGRATION

Standard business requirements

Standard business requirements are:

– guaranteed delivery of messages and single;

– reliable operation with network, software and hardware faults (fault tolerance);

– high performance;

– short development cycle for the integration project;

– the ability to easily build and reuse components;

– low cost of ownership and maintenance of the system.

Standardization of data

Standardization of data is concluded:

– as a standard message, body accepts standard XML;

– as a standard interface, description system accepts standard XSD;

– as a standard, modified standard XML messages accept XSLT;

– as a first access to the message body language, take XPATH.

These standards are well established and have wide support.

In practice, not all systems support XML-interface for data exchange. In this case, it is necessary to use ASB transformation services message format in XML-messages.

If $C1$ and $C2$ formats – not XML, the converters may be a specific software product. Nevertheless, even in this case, the conversion from XML in a simple straightforward format (e.g., comma delimited) can be performed using XSLT-transformation. Steps to change formats you can easily make at the ASB level. Received by ASB data will be converted to the intermediate XML format, and the output will be converted to the format of the recipient. Application systems themselves do not need to be reworked in this regard, because all conversions are performed at the level of ASB.

If the format is XML, the conversion can be performed by means of XSLT transformations.

The most common mode of transmission was and is still is working through the files. Some systems for interaction do the following: perform a data dump of $C1$, file transports by mail or through the carrier and loads into $C2$, and all operations are performed manually. This process does not meet the requirements of modern business.

It is necessary to have files adapters that will pick up files from some directory and send them as messages to the server messages queue of ASB. They also must adjusted to accept messages from the server messages queue.

The best variant is adapters, invariant to the OS , for that purpose are perfect adapters, realized in JAVA. The invariance of the software is very important because there are many products that work not only on Windows, but also on Linux, AIX, Sun Solaris, and others. Mostly, it does not matter which operating system is required for the server messages.

Having defined the general scheme of interaction modules, you must determine what kind of formats and data types used in today's CAD systems.

In different types of CAD formats use different writing data. For example, image data recorded in the different CAD systems in the form of vectors (AutoCAD, a compass), and in the form of objects (SolidWorks). These record formats reflect declarative component design data P. Tables, text, mathematical formulas, used to describe the definition of the object and thus are included in P.

$$P = P_g \cdot P_{tb} \cdot P_b \cdot P_m, \qquad (1)$$

here P_g is graphical; P_{tb} is tabular; P_b is textual; P_m is mathematical aspects of the data representation.

Declarative representation of the data reflects the essence of the object in the description of its static parameters. Parameters such as size, weight, material allow clearly and unambiguously define the steady state of the object. Usually the result of an object design using CAD is set just such data. In the process of designing a static description of the object plays a big role. Designer in the design process solves the problem of constructing an object from components, combining them with the static parameters.

Many data formats used by different software from different vendors, and therefore these formats have become a kind of standard. Such as, for example, dwg [5] – graphic presentation format for AutoCAD and Autodesk's Compass, db and dbf formats for tabular data systems dBase, Clipper, Paradox, sql format for relational databases MySQL, MSSQL, doc and rtf formats for text data in a word processor from Microsoft Word and many others.

In most CAD commands are used for constructing the standard elements of the set X, and usually record formats similar teams in different CAD systems coincide. Write commands graphics reflect procedural component design data processing commands T tables, text, mathematical calculations are also included in T.

$$\boldsymbol{T} = T_g \cdot T_{tb} \cdot T_b \cdot T_m\,,$$

here T_g is numerous commands of the graphic processor; T_{tb} is numerous commands spreadsheet processor; T_b is numerous commands word processor; T_m is numerous commands mathematical processor.

Solution of the problem is the construction design of the coupled system descriptions of circuit elements. Operator implements communication between the descriptions of objects from a set of standard elements of X. For example, the standard elements of "point" and "line" may correspond to the operator "starts" that implements the expression "line starts with a dot."

In summary, the system descriptions of the design object as follows:

$G = (P, T, K)$, where, P, T are set of design object descriptions; K is stereotyped relations between descriptions of the object.

The presence of G in the T component creates preconditions for the unification (integration) procedural data object to be created, cultivated in different systems and automation tools.

Thus, for example, the line being one of the elements of the assembly drawing, described in terminology reflects graphical aspect P_g declarative components P design data from a set of X standard elements. Command of the program processor that implements the construction of the line reflects the graphic aspect of the procedural components of T_g in T project data from a set of X standard elements that formed and description of the proposed facility. Construction of the line relative to other standard cells is regulated by a variety of drawing operators P, interoperable drawing elements from the set X of standard elements. Similarly, for other aspects of data.

Consequently, in modern CAD are implemented various ways to specify data, acceptable to design documentation, and created the preconditions for the development of methods and means of dynamic data integration.

Making an analysis of the above, we can draw a block diagram of a generalized conditional on CAD, which can be traced as the exchange of information flows (Fig. 4).

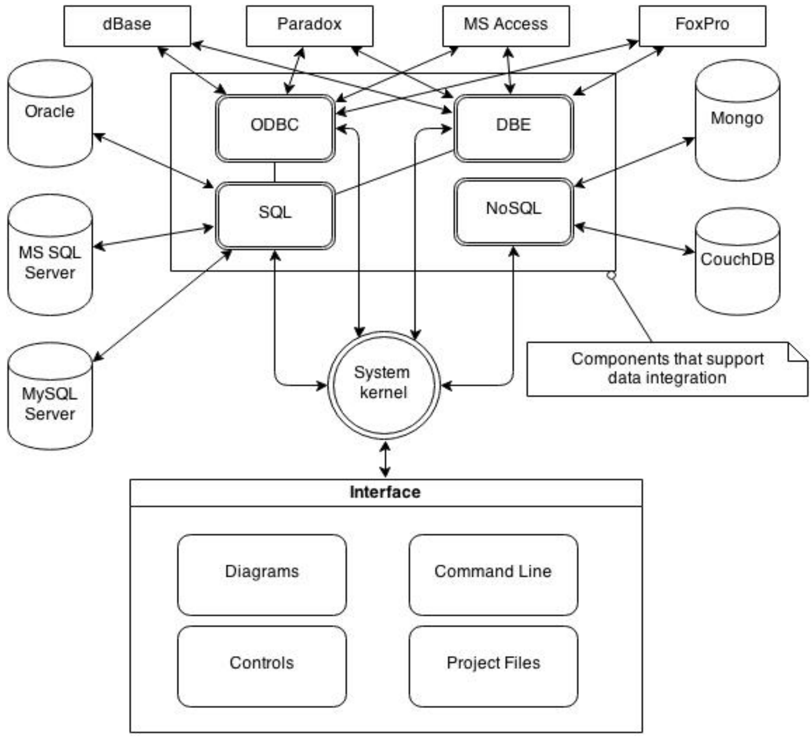

Fig. 4. Scheme of CAD

Figure out how information is generated in CAD, understanding its structure, you can choose a means of integration and interaction of diverse data in the context of the integration of several CAD systems into a single system.

Usually, two methods for data integration are considered in a single information process [4]:

– the method of static data integration;

– method for dynamic data integration.

Static method of data integration is designed to link and embed one type of data, processed by specific software tool, in another software tool. Herewith, data acquisition is implemented as a link to the results of commands. Influence on the course of executing the command in the method of static data integration is not allowed. With static data integration system operates specific parameters of objects and implements communication only between the parameters of objects. At the same time, in the system one parameter of any object is usually separated from the command and is an independent part of the object, independent of any command.

Method for dynamic data integration is designed to bind a command or group of commands in one software tool, which is the result of a value of a specific data type, with commands of other software tools in a single information process. Both considered software tools have equal rights. Interaction is determined by the terms of the order process and information requirements. With dynamic data integration system operates commands forming parameters of objects and implements communication objects directly between the modules, while providing a more flexible way of combining and "understanding" of different types of data. In the system one parameter of any object should not be separated from the command. This parameter is only a formal representation of data in the system.

Let us consider some CAD position with the completeness of these methods in both static and dynamic integration.

A variety of known CAD, such as Compass-3D, implement design automation at the transaction level with declarative data and facilities for the implementation of elementary actions. Designer's work in this case only partially automated as automation of procedural data remains outside the scope of possibilities of CAD [5]. Procedural details of the project are displayed in the event log, which does not offer the designer the ability to manage procedural project data. Since the design process without procedural data processing is complete, the problem lies entirely on the person. In this type of CAD neither static nor dynamic data integration is not implemented and executed by the designer manually.

In CAD, objects with parameterized data relationships are more complex. Method of data parameterization is data binding declarative representation interconnected by certain functions. Parameterization result is the construction of a chain of interconnected objects. This method of constructing objects represents the designer more control over the design and modification of the proposed facility.

Computer-aided design, using parameterized data have in their architecture to monitor, tracking project status. The monitor displays the process of creating an object and allows rebuilding related objects after changes. If during the design process it is necessary to change the data in one of the elements of the chain of related objects, the monitor provides automatic changeover related subsequent objects. Usage of the monitor for CAD designer provides a powerful new mechanism to not only track produced by action, such as, in the event log, but also to manage the project.

Object parameterization capabilities in the system can get the effect of the status tracking of the objects. Designer at any time has the ability to make changes to one of the objects of the project without worrying about related objects. Thanks to the parameterized objects and control monitor, the system itself rebuilds all related objects.

Principles of programming objects used in such CAD as DiaLux, Altium Designer. Each elementary object has a set of parameters characterizing his condition: size, material, etc., which are declarative information. All objects have a basic means of communication with the same objects. Thanks to these, communication objects can be grouped into so-called “an assembly”.

Means of objects communication is an elementary function of a standard set of system functions. Communication functions of objects differ in the types of geometric objects overlap each other. Differ functions that implement a connection point, the connection for the line connection on the surface, etc. The difference between these functions is the number of parameters of the connected objects being compared. Depending on the comparison result, monitor certain actions implemented.

Construction of elementary object in a CAD DiaLux made by setting a particular surface and its subsequent change through various graphical commands [6].

For example, when constructing a parallelepiped, contour is defined first in the form of a rectangle, then performs an operation of stretching, pressing, pulling, etc., associated with the box. The specificity of this method of communication does not allow to use it for representation of other aspect except graphics. In this and similar CAD certain steps were taken to solve this problem.

Computer-aided design Altium Designer provides the ability to connect different software using standard Windows communication options [7]. Thus, the user can own database object parameters, and use them in the design process. With the tools of DDE/OLE database fields are connected to the parameters of an object and at the moment when formation of the parameter is done, data from the database is recorded in a particular setting. Since the formation of databases provided by CAD Altium Designer, is an external process, parameterization is not covered. Consequently, the benefits of parameterized objects provided by CAD Altium Designer for graphic data are not available for tabular data.

The main principle of the objects in the system is based on operations with declarative data object. The basis of the design process in CAD Altium Designer is the consistent execution of commands, parameters of which are aligned with the parameters of designed objects. Considering the principles of objects and principles of the projects implemented in CAD parameterization with objects, you can establish that the object parameters and parameters performed during the design commands are separated from each other. The same parameter can be obtained by using different commands of CAD. This parameter is not only a formal representation of the object in the system. List of parameters and represents object in the system. After executing a command result is stored in the parameter list of the object. Further, when performing a command parameter object will be processed with a combined command parameter. The result is stored in the parameter list of the object and so on.

Having considered of all listed above properties of CAD objects with parameterization can infer the presence of these CAD data integration. However, in such CAD object parameters and commands are separated from each other, object parameters have priority over commands and they are not only a formal representation of commands to the system. Consequently, the CAD data with the parameterization can be realized only by static data integration methods. These CAD include monitor that provides tracking status of parameters and generating automatic rebuild facilities.

In all listed above CAD there are no conditions for the implementation of dynamic data integration. However, these CADs software have open (or partially open) architecture and have the ability to bind with different software. Implement dynamic data integration may create a specialized add-on software that performs the communication between the commands, creating the projected object.

Software package with add-ins that implement the economic integration of the data is a computer-aided design environment in which there are software tools that handle different aspects of the data representation. An example of such an environment is an integrated CAD environment.

The basis of management methods of procedural sets in integrated environment of CAD is monitoring of system events in accordance with the interpretation of descriptions of design processes (design scenarios). As a result, design events are displayed in the sequence of program procedures of information resources that provides integrated conversion on descriptions of objects.

In our integrated CAD environment foundation techniques for creating user applications is logging procedural events. Protocol is used for the construction of generalized chains of events in the form of automated design procedures that are structured in the system's database and communicate with descriptions of project processes. The possibility of building executable code of the design procedures based on a compilation of procedural libraries environment. This allows you to create software components and application systems to expand the range of standardized design operations.

Computer-aided design with integrated environment allows you to:

– allocation of change management operations into a separate software component – the core environment, implementing functions: management tools environment; resource management and computer peripherals; control information exchange; user dialog exchange;

– integration of operations on the same type of information to describe a single software system, component tool of the environment fund;

– support of tools that implement the operations of union and binding fragments of information descriptions;

– support of complex equipment to ensure the expansion of the environment.

Completeness of information about object descriptions in an integrated CAD environment provides a variety of information processes, implementing operations, such as:

– the graphical aspect of object descriptions - the graphics processor;

– tabular aspect of object descriptions - table processor;

– textual descriptions aspect object - a word processor.

Regarded CAD with an integrated environment has the following properties:

Completeness and integrity of the design object descriptions, provides integrated transformations.

Simplicity and convenience of operation of writing, design procedures, it builds descriptions of many alternatives – integrated project operations.

Flexibility of design processes, provides a flexible framework of descriptions of design procedures that allows you to manage transitions scenario design and modify the contents of responses to possible events.

A variety of classes of design operations in accordance with the level of complexity of project tasks and qualifications assure the combination of design operations and their use as a whole.

Simplicity and convenience of operations for the joint processing of graphics, text and spreadsheet object descriptions.

Support and combine object-oriented and subject-oriented descriptions of design processes with the ability to connect descriptions of the processes.

Evolutionary development, provide feedback based on the logging of user actions used in conjunction with data and their further structuring.

The accumulation of knowledge acquired for the subsequent synthesis of executable elements that allows developing evolutional system and configuring it to various classes of design objects.

Simplicity and convenience of management conversational interaction provides a unified operations dialog interaction kernel environment and a textual description dialogue procedures.

VI. Conclusion

Presented CAD with an integrated environment introduces a new approach to managing the design process. Used in the proposed medium scenario design can greatly simplify the work of the designer. Available in medium monitor provides the flexibility of design processes with a flexible structure description of design procedures in the scenario design. Properties listed above for such CAD, coupled with the ability to integrate data of various aspects of presentation in a single information process, this system is isolated in a special class of software employed to integrate heterogeneous data.

However, investigated CAD with integrated environment does not have sufficient properties to assign a class to its CAD implementing dynamic data integration. This system is a tool for creating applied (final) CAD. The system has all the advantages presented only in the process of creating the ultimate CAD. During the operation created the ultimate CAD provides the designer the opportunity to log only project operations not provided for scenario planning.

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В. М. Синєглазов, А. П. Годний. Динамічна інтеграція даних при проектуванні систем автоматизованого проектування

Представлено інтегроване середовище системи автоматизованого проектування, яке реалізує новий підхід у керуванні процесом проектування. Використовуваний у запропонованому середовищі сценарій проектування дозволяє істотно спростити працю проектувальника. Наявний в середовищі монітор забезпечує гнучкість проектних процесів за допомогою гнучкої структури опису проектних процедур в сценарії проектування.

Ключові слова: динамічна інтеграція; система автоматизованого проектування; інтегроване середовище; проектування.

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В. М. Синеглазов, А. П. Годний. Динамическая интеграция данных при проектировании систем автоматизированного проектирования

Представлена интегрированная среда системы автоматизированного проектирования, которая реализует новый подход в управлении процессом проектирования. Используемый в предложенной среде сценарий проектирования позволяет существенно упростить труд проектировщика. Имеющийся в среде монитор обеспечивает гибкость проектных процессов с помощью гибкой структуры описания проектных процедур в сценарии проектирования.

Ключевые слова: динамическая интеграция; система автоматизированного проектирования; интегрированная среда; проектирование.

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