DEVELOPING OF DISTRIBUTED VIRTUAL LABORATORIES FOR SMART SENSOR SYSTEM DESIGN BASED ON MULTI-DIMENSIONAL ACCESS METHOD

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Abstract: In the article it is considered preconditions and main principles of creation of virtual laboratories for computer-aided design, as tools for interdisciplinary researches. Virtual laboratory, what are offered, is worth to be used on the stage of the requirements specification or EFT-stage, because it gives the possibility of fast estimating of the project realization, certain characteristics and, as a result, expected benefit of its applications. Using of these technologies already increase automation level of design stages of new devices for different purposes. Proposed computer technology gives possibility to specialists from such scientific fields, as chemistry, biology, biochemistry, physics etc, to check possibility of device creating on the basis of developed sensors. It lets to reduce terms and costs of designing of computer devices and systems on the early stages of designing, for example on the stage of requirements specification or EFT-stage. An important feature of this project is using the advanced multi-dimensional access method for organizing the information base of the Virtual laboratory.

Keywords: Virtual Laboratory; Computer-Aided Design; Access Methods; Distributed System.

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Introduction

Fast spreading of market relations and competition between manufacturers of different (including scientific) production and information services makes very actual the acceleration of development of theory and methods of computer-aided design of computer devices and biosensors. Actual design of devices and systems, which is often used, needs a lot of time, material and human resources. If one needs to make a small set of devices by means of actual design, the price of final production becomes very high. Therefore, manufactures of computer devices get very complicated issue, which consists in time and price reduction of new devices design. Only after solving of this issue the new devices of own design will be able to become competitive on domestic and world markets.

To minimize these design expenses to reach high level of competitive recently side by side with actual design it is begun to use a virtual design. These methods realized by means of virtual laboratories of computer-aided design (VLCAD), which are based on advanced access methods and worth to be used on the stage of the requirements specification or EFT-stage, because it gives the possibility of fast estimating of the project realization, certain characteristics and, as a result, expected benefit of its applications.

Market analysis and joint discussion confirm the acute necessity in the developing of new virtual design methods and in the creating on their base open VLCAD, main feature of which is possibility to use such remote laboratory by specialists in different science branches, without education in information technologies and instrumentation.

Preconditions and Main Principles of Virtual Laboratory Creation

One of problems, which are met by developers of new devices for different fields of science and engineering, is existence of more than 15 thousands of such fields or disciplines to date. Naturally to carry out researches or create a new device developers must have knowledge from disciplines, which refer to developed device. Therefore it is important to orientate new computer technology for interdisciplinary researches, which occur on boundary of several science fields or disciplines.

Urgency of these researches is caused by absence of computer technology of smart devices designing for interdisciplinary researches in Ukraine and Bulgaria. It does not allow to test on computer models the performance of designed devices, which are created on the base of new effects or sensors. To date to develop new device or to check the possibility of its creations and operation it is necessary to invite specialists in information technology, electronics and circuit technology on the commercial base. Getting results in such way is very expensive and, as usual, is not supported with necessary funds. This again confirms acute necessity of design technology development and creating on their base the open virtual laboratories, the main feature of which is possibility to use these virtual laboratories by specialists from different science fields, especially non-specialists in the field of information technology and instrument making.

Good solution of this problem is to create on the base of information technologies the special hardware-software tools [Palagin and Sergiyenko , 2003], which in convenient mode (for example, with help of dialogues) allows sensor developer to check possibility of creating of new devices and the device model. Such tool has to give possibility to create a model set of certain device (e.g. functional, electrical, operational etc.), including prior parameters calculations, project of circuit board and set of design documentations (e.g. cost, performance, validity, size, reliability etc.). Description of sensor or its model should be incoming data for such design system.

Now on the world market there are a lot of software for computer-aided design (CAD), which allow to automotive design of new devices and systems and analyze them in different ways [Gavrilov, 2000]. But for skilled usage of such CAD software it is necessary to have special skills in circuit technology, electronics and instrument engineering, and also know this CAD software perfectly. It is clear, that sensor developers, who are mainly chemists, biologists, biochemists, physicists etc, have no enough possibility and skills to use such complicated CAD software for designing of new devices on basis of developed sensors. In such case they need help of CAD specialists. But it is very expensive service. Therefore in most cases sensor developer leave sensor "in quiet" and switch his attention to another tasks.

It is necessary to note, that only by paying attention to the design process of computer devices it will be possible to reach a high level of competitiveness of scientific developments, what lets in the future to take up notable place on the world market. It is easily to see, that most devices have the same structure, to be exact, they consist of sensor, measuring channel, data processor, interface and additional subsystems. That’s why process of designing could be easily formalized.

To solve this problem within the bounds of international Ukrainian-Bulgarian project it is began developing of virtual laboratory for computer-aided design for computer device designing [Palagin et al, 2007]. The VLCAD is being created on the virtual methods of design [Galelyuka, 2008]. Offered virtual laboratory are created on the base of formalized representation of theoretic knowledge, principles of organization, methods and facilities of computer-aided design and testing information-measuring systems and devices, in particular on the base of subject field ontology. For VLCAD creating it is used the methodology of system integration [Palagin and Kurgaev, 2003] concerning base methods and tools, on which it is created. In the methodology basis it is putted system approach to tasks of analysis and synthesis of both VLCAD component and object of designing, and, first of all, forming knowledge system of interdisciplinary nature and its computer ontology. Proposed VLCAD is open system.

Mentioned VLCAD allows sensor developer to:

- check possibility of creating of devices and computer facilities (including portable devices) on basis of developed sensors without involving specialists in circuit technology and instrument engineering at the stage of EFT-project. It allows reducing terms and costs on this stage;
- avoid expensive actual tests on the stage of device creating by replacing with virtual methods of designing and testing;
- prepare set of design documentations on designed device in the automotive mode without involving corresponding specialists. Next stage is to send design documentations to contract production for creating of test party of devices.

Terms "Virtual laboratory" and "Virtual design" appear lately, so, as usual, they are absent almost in all dictionaries. The word "Virtual" appeared in word literature a long time ago. "Virtuality" has almost all features of empirical reality with the exception of its direct presence. So, it is "reality, which is absence" or "present absence". Also, "virtual" is one, which has no physical embodiment. "Virtual reality" is comprehended as a part of reality, which is modeled by computer device. Since any laboratory is a part of reality, so taking into account above-stated, there can be formulated next term of "virtual laboratory": virtual laboratory is imagined laboratory, which has all features of real laboratory and is modeled by means of software and hardware.

In general, virtual laboratory is some information environment, which lets to conduct researches in the case, when there is no direct access to test subject. Researches can be conducted by means of mathematical models and with using of remote access to test object.

Somebody may work with physical objects in two ways:

- emulation of physical objects with defined level of approximation to reality;
- remote access to physical objects with defined capabilities of interacting.

The first method lets to get completely virtual analog of some environment, what is very practical. Disadvantage of this method is complexity of model creating, which is very approximate to reality.

The second method provides maximal approximating to reality. But it requires creating and supporting of remote access to test objects, but the number of access channels is limited. Server of laboratory setup, besides access to equipments, is able to give background and methodological materials to researcher. Remote experiment in most cases is conducted in such way. Researcher communicates laboratory setup server and send data for experiment. Server software conducts experiment and sends results as tables, graphics to researcher.

For realization of VLCAD it is decided to use the first method. But the second method is not set aside and in future it will be probably used as additional tool.

Virtual laboratories, in which experiments are conducting by means of mathematical models, differ from previous one by using mathematical or other model instead of real test object. These laboratories have no laboratory setup.

Creating of VLCAD

Before VLCAD creating, first of all, it is necessary to determine features of VLCAD as tool for interdisciplinary researches and what functions it has to have.

In general, VLCAD is a system for computer-aided design, but with certain difference. This difference is that for using any CAD system it is necessary to have deep knowledge in this software, instrument engineering, circuit technology and electronics. It is expected, that for using VLCAD users need only experience in work with computer. Design process by means of VLCAD is much regulated and is going on dialog mode with additional help messages. So, the main feature of VLCAD as tool for interdisciplinary researches is orientation of this system in the side of usual users, which are nospecialists in the field of information technology, instrument

engineering and circuit technology. It make practicable to develop new device or verify possibility of such development by such specialists, as biologists, ecologists, medics, biochemists at el.

For such VLCAD creating, first of all, it is necessary to execute next actions:

- improve design process on the base of using mathematical methods and computer tools [Palagin et al, 1993];
- automate process of searching, processing and issuing of information;
- use methods of optimal and variant designing, effective mathematical models of design object, components and materials;
- create multi-dimensional hierarchical databases with integrated data of reference type, needed for computer-aided design;
- improve quality of designed document execution;
- increase creative part of designer work at the expense of automation of noncreative routine work;
- unify and standardize design methods;
- train specialists, including students, masters etc.;
- implement interaction with automatic systems of different levels and purposes.

To define place of VLCAD in the design process it is necessary to take into account world experience of design engineers of computer and portable devices. Integrated scheme of design process with proper outlet documentation and the place of VLCAD in design process are shown on fig. 1. As one can see VLCAD covers early stages of designing.

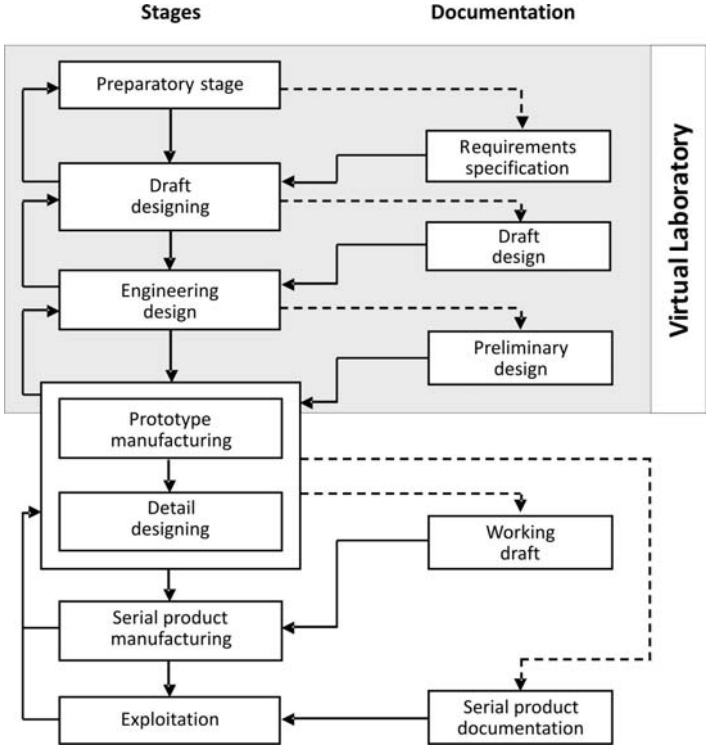

Fig. 1. Integrated scheme of design process with proper outlet documentation

Since VLCAD has many features of CAD system it is rationally to use methodology of CAD system creating during VLCAD developing, but taking into account features of VLCAD. It is necessary to note, that now there are several conceptions of CAD system creating. Full-automatic and man-machine systems are the most widespread. First systems are difficult to build and, in some cases, it is impossible to create such full-automatic system, because design process is heterogeneous, has many internal and external connections and includes a lot of undefined factors. To take into account these undefined factors it is necessary to use creative opinion of designer.

Taking into account described above we can state, that creating of VLCAD for computer device design is very important scientific-technical problem, and implementation of such VLCAD needs certain investment. Received experience and analysis of world literature let us to separate out next main principles of such virtual laboratories creating:

1. Virtual laboratory is man-machine system. All design systems, which had been developed and now are being developed, are computer-aided, and designer is the main part of these systems. Human in such systems has to solve tasks, which cannot be well defined, and problem, which human by using own heuristic abilities may solve better and more effective than computer. Close interaction between human and computer during design process is one of principles of development and exploitation of any CAD systems for computer device designing.

2. Virtual laboratory is hierarchical system, which use comprehensive approach to automation of all design levels. Level hierarchy is presented in system structure as hierarchy of subsystems.

3. Virtual laboratory is set of informational-concerted subsystems. This very important principle refers not only to connections between large subsystems, but to connections between separate parts of subsystems. Informational compliance means, that almost all possible sequences of design tasks are served by informational-concerted programs. Two programs are informational-concerted if all data in these programs are part of numeric arrays and do not need transformations during sending from one program to another and inversely. So, results of one program can be incoming data for another program.

4. Virtual laboratory is open system, which are permanently expanding. Permanent progress of technology, designed objects, computer technology and computational mathematics lead to appearance of new, more perfect mathematical models and programs, which replace old analogs. So, VLCAD has to be open system and be able to use new methods and tools.

5. Virtual laboratory is specialized system with maximum using of unified units. Requirements of high efficiency and universality for any system are, as a rule, conflicting or competitive. It is reasonable to develop VLCAD on the base of unified parts. Necessary condition of unification is searching of common principles in the modeling, analysis and synthesis of technical objects.

Computer technology, what are offered by us, is hardware-software complex, what consist of personal computers or work stations with set of necessary peripheral items, connected in local and worldwide networks, such as Internet, and is supplied with all software. Using of these technologies already increase automation level of design stages of new devices for different purposes, including devices for interdisciplinary researches.

Today such complex systems, as VLCAD and CAD, are developed as knowledge-oriented systems, main feature of which is informational integration. Informational integration is the main application area of ontology using. Ontology, as a rule, contains hierarchy of concepts of knowledge domain and describes important features of every concept by means of mechanism "attribute–value". Connection between concepts may be described by means of additional logical statements. Constants refer to one or several concepts. This and another ontology features let to use ontology in different fields of knowledge, increasing effect from application of different methods and modes of work with information or creating on their base new more effective methods [Palagin, 2005]. Especially efficiency of ontology application can be shown in such science intensive fields, as knowledge engineering and knowledge management, objects and processes modeling, databases designing, informational integration and data mining [Gladun, 1994].

Analysis of literature and certain application domain lets to specify requirements to ontology, on the base of which VLCAD is developing [Palagin et al, 2007], [Galelyuka, 2008]:

- Ontology has to include conceptual knowledge, but not episodic ones.
- Ontology has to be specified and internal concerted with structure, names and content for all defined conceptions.
- Ontology has to be structured and simple for understanding and searching of conceptions.
- Ontology has to be limited by certain application domain for defining of used conceptions. Ontology has not to include all possible information about application domain.

VLCAD storage space

As a storage space for VLCAD a multi-dimensional access method, called ArM32, property of FOI Creative Ltd. may be used. It is built on the base of the Multi-Domain Information Model (MDIM) [Markov, 2004].

The ArM32 elements are organized in a hierarchy of numbered information spaces with variable ranges. There is no limit for the ranges the spaces. Every element may be accessed by correspond multidimensional space address given via a coordinate array.

The Multi-Domain Information Model (MDIM), presented in [Markov, 2004], is a step in the process of development of tools for data-base organization. Its main idea is to permit practically unlimited access to multi-dimensional information structures. In MDIM there exist two main constructs – numbered information spaces and basic information elements.

The Basic information element is an arbitrary long string of machine codes (bytes). When it is necessary the string may be parceled out by lines. The length of the lines may be variable. In ArM32 the length of the string may vary from zero up to 1GB. There is no limit for the number of strings in an archive but theirs total length plus internal indexes could not exceed the limit for the length of a single file of the operating system.

Basic information elements are united in numbered sets, called numbered information spaces of range 1. The numbered information space of range n is a set, which elements are numerically ordered information spaces of range n-1.

ArM32 allows using of information spaces with different ranges in the same archive (file).

The main ArM32 operations are reading, writing, appending, inserting, removing, replacing and deleting of a basic information element or any it's part.

The ArM32 numbered information spaces are ordered and main operations within spaces take in account this order. So, from given space point (element or subspace) we may search the previous or next empty or non empty point (element or subspace). In is convenient to have operation for deleting the space as well as for count its nonempty elements or subspaces.

ArM32 engine supports multithreaded concurrent access to the information base in real time.

Very important feature of ArM32 is the possibility not to occupy disk space for empty structures (elements or spaces). Really, only non empty structures need to be saved on external memory.

Conclusion

For increasing of competitiveness of science products it is necessary to develop new hardware-software tools, what is applicable for using in interdisciplinary researches. Virtual laboratory for computer-aided design can serves as example of such tool. In the article it is considered preconditions and main principles of such virtual laboratories creation, main purpose of which is to give possibility for sensor developers to verify ability of creating new devices on the base of their sensors on the early stages of designing, particularly on the stage of requirements specification or EFT-stage.

The features of ArM32 are appropriate for building the information base of VLCAD. The multi-dimensional information spaces make possible the effective creating of complex information structures using small amount of resources which is very important for VLCAD. At the first place the ontology's' representing and knowledge formation processes as well as intelligent recognition and classification are realizable.

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