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# Structure and Organization of Typical Virtual Laboratory for Computer-Aided Design

O. V. Palagin, I. B. Galelyuka, V. O. Romanov
V.M. Glushkov Institute of Cybernetics of National Academy of Sciences of Ukraine,
40, Academician Glushkov prospekt, Kyiv-187, 03680, Ukraine,
galib@gala.net, d220@public.icyb.kiev.ua

***Abstract*** *– In the Institute of Cybernetics of National Academy of Sciences of Ukraine the conception of virtual laboratory for computer-aided design was developed. The structure, organization and advantages of typical virtual laboratory are described.*

***Keywords*** *– CAD, portable device, virtual design, virtual laboratory*

## I. INTRODUCTION

There are a lot of medicine, biology, biochemistry effects for creating of noninvasive portable devices for wide and everyday use: glucometers, hemoglobinometers, devices for rapid analysis of foodstuff, liquids, environment parameters etc. Modern microelectronic components let to create devices which have a small size and use a little of electrical energy, but such devices have high metrological and servicing characteristics.

Full-scale design of such devices demands a lot of time, material resources and manpower. One may minimize these outlays with help of methods of virtual computer-aided design (CAD). These methods are realized through the virtual laboratory for computer-aided design (VLCAD).

## II. FUNDAMENTALS OF VLCAD'S

Modern VLCADs can be divided into two kinds of laboratories: for general and special purpose. First ones are used for designing devices for wide purposes. Last ones are used to design devices and systems for special application, for example, devices and systems, which are used in biology, medicine, ecology etc.

VLCADs have some advantages:

1) Cheapness of design, because the expensive and complicated equipment are not used and expensive actual tests are not fulfilled.

2) Speed of design, because samples and models are already prepared before.

3) Possibility of creating several alternative variants of device at the same time and choosing optimal variant from them.

4) Possibility of working of geographically-distributed specialists around one project. The possibility of exchange of experience between specialists is very important and useful in modern time.

5) Possibility of using VLCADs for training future specialists.

6) Possibility of creating and filling bases of knowledge in the process of designing and training.

VLCAD is used not only for designing and development of certain devices, but also for estimation, testing of work hypotheses, experimental researches. VLCAD is worth to be used on the stage of the requirements specification or pilot-project, because it gives the possibility enough fast to estimate the project realization, certain characteristics and, as a result, expected benefit of its practical realization. On the stage of design VLCAD lets to decrease both time and cost of the design.

VLCAD lets not only to design device or system, but also to optimize their features for achieving certain (expected) ratio “precision/cost”, “precision/reliability” etc. (for example, by selection of elements etc.) without using expensive actual tests and expensive equipment.

Unfortunately, there aren't almost VLCADs, which let specialists in medicine, ecology, biology, biochemistry to create their own devices on the base of effects, which are chosen by them.

## III. CONCEPTION OF VLCAD

To solve this problem the conception of virtual laboratory for computer-aided design (VLCAD) of computer devices and system for biosensor researches was designed in the V.M. Glushkov Institute of Cybernetics of National Academy of Sciences of Ukraine.

Offered conception of VLCAD is 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. By formalized representation we mean computer ontology of mentioned subject field (in its extended and narrow types), which architecturally looks as hierarchical (like tree) system, which includes base essences (concepts) linked by system of relationship (genus – species, element –

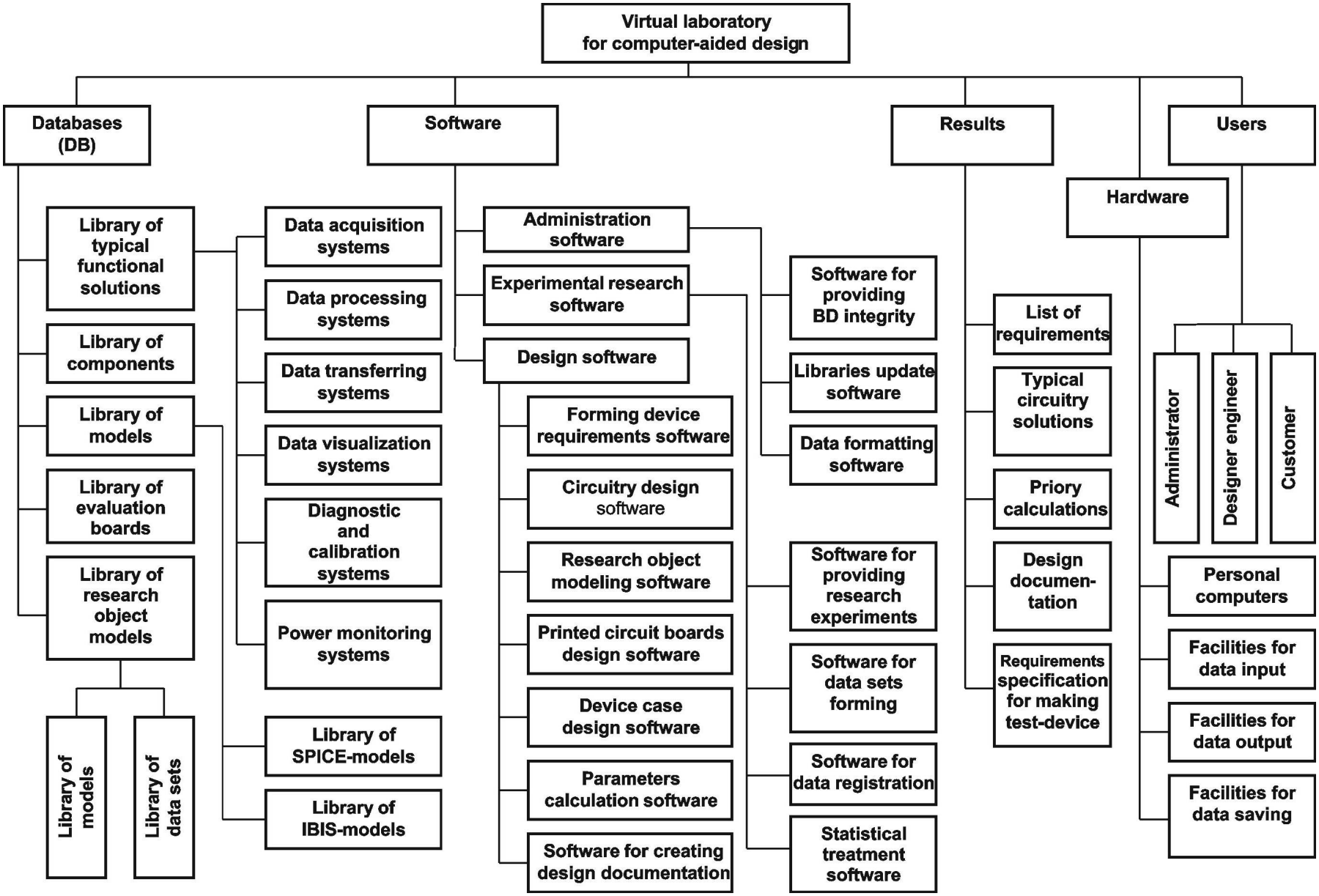


**Fig.1. Simplified representation of virtual laboratory for computer-aided design (from object region ontology).**

system, cause – result etc.) with full statement of contents (interpretation function) both concepts, and their relationships. Thus VLCAD is built as ontology-driven information system with extended possibilities of intellectual and information interconnection with remote user.

For creating of VLCAD there was used the methodology of system integration [1] relative to base methods and facilities, which it is built on. The base of this methodology is system approach to tasks of components analysis and synthesis of both virtual laboratory and objects of design, and first of all, forming of knowledge base of chosen problem area and its computer ontology.

Simplified representation of VLCAD is shown in Fig.1. This representation is built on the base of object region ontology, which is also created in the Institute of Cybernetics.

There are three main elements in the VLCAD structure: databases, software and hardware.

Databases involve all information, which is used in the design process of devices. Databases are divided into libraries [2].

There are next libraries in the structure of VLCAD:

1) Library of typical functional solutions, which encloses typical functional solutions for different systems, for example: data acquisition systems, data processing systems, data transferring systems, data visualization systems, diagnostic and calibration systems, power monitoring systems etc.

2) Library of components, which involves expanded information about microelectronic components of different manufactures.

3) Library of microelectronic components models. This library involves SPICE and IBIS models.

4) Library of evaluation boards, which includes also virtual evaluation boards [3].

5) Library of research object models (models of processes and effects in medicine, biology, biochemistry and other areas). This library is divided into research object models and corresponding data sets (input and output data). Library is used for realization of virtual experimental researches and providing their automation. Data sets are used for estimating of authenticity of research object models.

VLCAD software is supporting next operations:

1) Realization of all design stages, beginning from forming list of requirements to designing device and finishing by creating of design documentation;

2) Providing of normal work and administration of databases;

3) Automation of experimental researches. Thus, all software can be divided into design software, administration software and experimental research software.

As written above design software is used on all design stages and encloses software for: forming device requirements, circuitry design, research object modeling, printed circuit boards design, device case design, device parameters calculations, creating design documentation.

Administration software is used for: providing databases integrity to make normal and uninterrupted work of system; updating libraries from global network and different data mediums; formatting data in form, which is convenient for saving in databases.

Software for experimental research is used for automation of virtual experimental researches and estimating of work hypothesis. As shown in Fig.1 this software includes software for providing experimental researches, software for forming of input data sets, software for registration of output data and software for statistical treatment of registered data.

Hardware consists of personal computers (servers and work stations if there is distributed system), input/output facilities and facilities for information saving.

Process of device design has exact order of operations and includes next stages:

1) Forming requirements specifications of prospective device (for example, precision, efficiency, reliability, cost etc.);

2) Choosing research object model from library or creating new model (if it is absent) and testing its authenticity by means of sets of etalon data, analytical formulas etc.;

3) Circuitry designing of device on the basis of defined requirements;

4) Estimating of operating functions of the designed device and correctness of its work;

5) Previous calculating of designed device parameters (for example, precision, efficiency, reliability, cost etc.) and estimating calculated parameters for their compliance to defined requirements;

6) Designing of printed circuit boards and device cases;

7) Realizing (virtual) experimental research, tests; data registration and processing;

8) Manufacturing of evaluation board for actual testing of designed device;

9) Creating design documentation of developed device.

If the results of some stage are negative one has opportunity to return to one of previous stages. So both whole design process and every stage are iterated.

At any stage of designing the functions of interaction with user let to enter and get information in convenient for user form.

## IV. Example Of VLCAD's Application

The example of VLCAD's application can be shown by the example of portable device "Floratest", which was designed in V.M. Glushkov Institute of Cybernetics of National Academy of Sciences of Ukraine. The

simplified functional diagram of "Floratest" is shown in the Fig. 2.

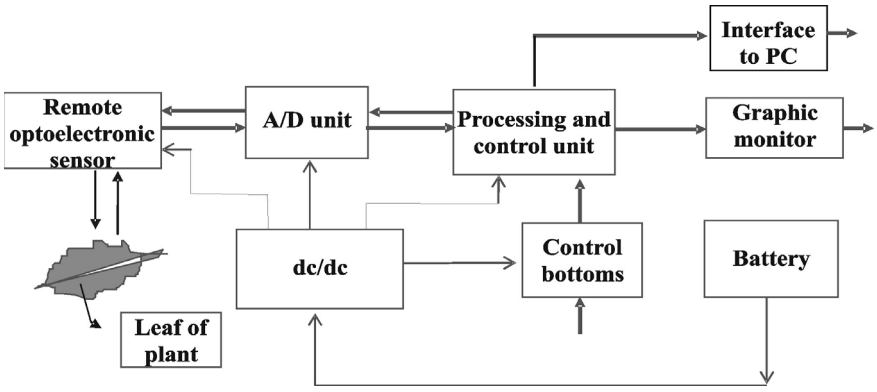


Fig.2. Functional diagram of portable device "Floratest".

First of all, we want to pay attention to the "leaf of plant". The work of device is based on effect of Kautsky [4] for measure of chlorophyll fluorescent induction of plants, which is described by analytic dependance. It makes possible to create effect model.

As there is no model of this element in libraries, we have to create this model and save it in the library of research object models. Saved model can be used in the future for designing of other like devices or for providing virtual experimental researches.

The "A/D unit" and "processing and control unit" are contained in library of data processing systems. The "remote optoelectronic sensor" is contained in library of data acquisition systems, the "graphic monitor" – in library of data visualization systems, the "interface to PC" – in library of data transferring systems. The "dc/dc unit" and "battery" are contained in library of power monitoring systems.

After finding in libraries and creating all models we link corresponding outputs and inputs of these models. Having linked all models we can estimate working of device and calculate device parameters for their compliance to defined requirements. Then we design printed circuit board and device case.

By means of VLCAD we can not only design devices, but also optimize certain parameters of designed device. We can do it, for example, with help of virtual evaluation boards, which are the important part of VLCAD.

Portable device "Floratest" works with two forms of signals: analog and digital. At first, the device measures analog signal and then transforms it into digital form with help of "A/D unit". The "A/D unit" consists of analog-to-digital converters. We use virtual evaluation board ADIsimADC™ (Analog Devices, Inc. product) to optimize parameters of high-speed analog-to-digital converters. The work of this board is based on analog-digital behavioral model, which delivers converters behavior taking into consideration almost all critical parameters: offset, gain, sample rate, bandwidth, jitter, latency, system interface signals and both altering and direct currents linearity etc.

As one can see, almost all models of device units can be chosen from corresponding libraries of VLCAD.

Using of virtual evaluation boards has next main advantages:

1) Parameters of microelectronic components can be estimated without using complicated equipments and expensive actual tests;

2) During a short period of time one can estimate parameters of many microelectronic components of different manufacturers and choose optimal one from them, which fits with certain requirements.

## V. CONCLUSION

Structure and organization of typical virtual laboratory for computer-aided design was considered in the article. The goal of creating virtual laboratory is to lighten work of design engineers and to make possible for scientists and specialists of different areas to develop their own devices, estimate work hypothesis and fulfil virtual experimental researches.

VLCAD lets to analyze the work of separated device units and to evaluate the work of whole device without using complicated equipment and expensive actual tests. Also it lets to reduce both cost and time of design, and that is very important now.

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