Web-Based Software Package for e-Learning and Research Training in Digital System Design

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Комплекс Web-средств для дистанционного обучения проектированию цифровых систем

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Тенденции развития системы подготовки специалистов в области электронной техники обуславливаются возможностями, предлагаемыми Интернет и связанными с этим принципиально новыми подходами к построению обучающих систем.
В основу работы проводимой в Таллинском техническом университете положена концепция разработки интерактивных обучающих модулей, которые характеризуются многоуровневостью и разнообразием затрагиваемых аспектов проектирования дискретных систем. Существенной особенностью предлагаемой системы является возможности для её применения в научных исследованиях, аппробации оригинальных теоретических решений. Предлагаемые средства дистанционного обучения являются платформо-независимыми и представляют собой совокупность JAVA-апплетов, что позволяет использовать преимущества соответствующей технологии построения программных средств.
Разработанный комплекс Web-средств нашёл своё применение в ряде зарубежных университетов.

ITRODUCTION

The recent years have seen a rapid emergence and broad acceptance of distance learning technologies. These technologies can be divided into two categories: synchronous or asynchronous. Both terms describe a type of communication between the instructor and the learners. Although synchronous technologies (video teleconferencing, online chat and telephone conference calls) are very useful, the constraint of real time communication is very limiting for most distance learners. A more attractive alternative is asynchronous distance learning. Asynchronous distance learning is the form of distance learning where the communication between the instructor and the learners is not required to occur in real time. Web-based instruction is the most attractive form of asynchronous distance learning because it can incorporate synchronous and asynchronous technologies [1, 2].

We present an original software package of digital design developed at the Department of Computer Engineering of Tallinn University of Technology for research and teaching purposes. We apply a learning method based on using interactive teaching modules. Our goal have been to develop Web-based tools so that they could be used in asynchronous-mode learning of digital design. We have selected the Java technology for our interactive teaching and training system since it is well supported by main operating systems. Java allows for graphical content to be easily created. It also has developed means for creating the user interface. Furthermore, Java applets are running on any standard browser connected to the Internet. The latter makes it easy for students from universities all over the world, to use this system at any time and in any place.

BASICS OF TEACHING METHODOLOGY

The principal mission of the conception is to inspire students to learn, and to encourage them for research training. There are several phases of the learning process supported by the educational system we offer:

- the reading (or listening) phase;
- the replication phase (students can use the interactive worksheets from any computer connected to the Internet and they are able to gain their own experience with the modules);
- the examination phase (the interactive worksheets are a good summary of problems the solution of which are necessary to the test);
- the practice phase (students have to solve digital systems problems; to develop required design skills they can use the interactive worksheets as a set of tools supporting several phases of the process).

The learning process initially presents the knowledge of the domain and progressively enhances the learner's competence in the application of that knowledge in a working environment. Our methodical approach is aimed at step-by-step involvement of students into design topics. In every level of knowledge they get the possibility to repeat experiments demonstrated by the instructor as well as to create own examples and to make own experiments. That is why we create the applets for teaching basic knowledge in the form of "Living Pictures". Those applets simulate tricky, quite complicated situations of the learning subject in a graphical form on the computer screen. The graphics is self-explanatory and provides interaction possibilities. By using these possibilities the students can generate examples that are interesting enough to encourage their own experiments [3].

SYSTEMS OVERVIEW

Web-based tools support learning and training via internet of the following digital design and test issues.

A. *Advanced topics of design, test, and design for test*

Entering the SoC era with its new concepts means teaching at higher levels of abstraction. The developed register-transfer level design and test applet allows to solve and illustrate many problems related to control intensive digital design and test [4]. The applet has a built-in extendable collection of examples implementing different algorithms. They help users to understand the principles of the system operation. For connecting the system to other applications as well as for providing users with a possibility to save the results of their work for further use the applet has a data import/export capability.

The range of problems includes: design of data path and control path, investigation of trade-offs between speed and hardware cost, register-transfer level simulation, fault simulation, test generation, design for testability and Built-In Self-Test (BIST).

B. *Controller decomposition*

The formal description of the control unit is a FSM which generates control signals to activate different operations in specific clock cycles. FSMs have been widely used also to express algorithms, communication protocols, digital systems, sequential logic circuits, and sequential logic cells. This part of learning system focuses on a particular but comprehensive problem of decomposition of FSM. Decomposition of FSM is a topic that is becoming more important with pervasive use of programmable logic in digital design. A large hardware behavioral description is decomposed into several smaller ones. One goal is to make the synthesis problem more tractable by providing smaller sub-problems that can be solved efficiently. Another goal is to create descriptions that can be synthesized into a structure that meets the design constraints. The continuing decrease in feature size and increase in chip density in recent years have given rise to consider decomposition theory for low power as new dimension of the design process. The developed applets we can use to carry out experiments on a set of well-known FSM benchmarks.

C. *Boundary scan learning*

After the students have learned the basic and advanced topics in testing they should finally get some ideas about modern testing techniques and standards used in industry. The main test strategy for SoC is the IEEE P1500 "Standard for Embedded Core Test." This standard has evolved from the earlier development in this area, namely, the IEEE standard 1149.1 "Test Access Port and Boundary-Scan Architecture", which was created by Joint Test Action Group (JTAG) and aimed at testing PC-Boards [5]. It is of no doubt that these very important new standards have to be taught to future designers and test engineers.

The presented system demonstrates principles of testing chips, which have a Boundary-Scan structure inside. It provides that the user can experiment with a built-in collection of chips and boards, load those interesting for him directly from the Internet and combine his own boards.

CONCLUDING REMARKS

In our teaching system we succeeded to combine and illustrate many different problems related to digital design. This gives a unique possibility to teach all of them in a consecutive iterative approach. We apply the concept of "Living Pictures" when building up our teaching system. The main features of such a system incorporate: graphical representation of the learning subject, dynamic content, user-friendly interface, concentration on the most important topics in the simplest possible way, set of various examples, easy action and reaction, and game-like style of learning. Our methodical approach is aimed at step-by-step involvement of students into training and research activities in a common environment.

The system's built-in multilingual support ensures easy integration into teaching courses of universities over the world. The web-based part of the system is available at the URL: http://www.pld.ttu.ee/applets

REFERENCES

[1] J. E. Gilbert, "Arthur: an Intelligent Tutoring System with Adaptive Instruction," Ph.D. thesis, University of Cincinnati, 2000, p. 75.

[2] Jutman, A. Sudnitson, R. Ubar, and H.-D. Wuttke, "Java Applets Support for an Asynchronous-Mode Learning of Digital Design and Test," in Proc. 4th International Conference on Information Technology Based Higher Education and Training, Marrakech, Morocco, 2003, pp.397-401.

[3] A. Jutman, A. Sudnitson, R. Ubar, and H.-D. Wuttke, "E-Learning Environment in the Area of Digital Microelectronics ", in Proc. 5th International Conference on Information Technology Based Higher Education and Training, Istanbul, Turkey, 2004, pp. 278-283.

[4] S. Devadze, A. Jutman, A. Sudnitson, R. Ubar, and H.-D. Wuttke, "Teaching Digital RT-Level Self-Test Using a Java Applet", in Proc. 20th IEEE NORCHIP Conference 2002, Copenhagen, Denmark, 2002, pp. 322-328.

[5] IEEE 1149.1-1990, "IEEE Standard Test Access Port and Boundary-Scan Architecture," 1990.

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