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Information and Communication Technology in Instrumentation and Measurement - the Publishing Side

Remigiusz J. Rak
Institute of the Theory of Electrical Engineering Information and Measurement Systems, Warsaw University of Technology
Pl. Politechniki 1, 00-660 Warsaw, Poland
Phone: +48-22-660-7291, Fax: +48-22-660-5642, Email: rakrem@iem.pw.edu.pl

Abstract *– The article gives a review of modern tools supported developing and adopting of a new model of book in the field of Instrumentation & Measurement. It includes a short description of the structure of the electronic book. The last part presents some details concerned to web based distributed measurement systems, remote access to laboratory and virtual laboratory.*

Keywords *– ICT, electronic book, Java applet, distributed system, virtual instrument, virtual laboratory.*

I. INTRODUCTION

Many of modern trends in the area of Instrumentation & Measurement come from quite different branches of science and technology. In order to prove the reality of this statement let us trace the latest history.

Under the name: **Computer Science** we understand a science dealing with design, realization, verification, implementation and servicing of information processing systems, taking into account: software, hardware, organizational and human aspects. **Computer Engineering** means the wide implementations of computer science (in the society at all). **Information Technology** (**IT**) is the set of elements (computers, peripherals, networks) and tools (included software) as well as other technologies (included communication), providing versatile utilization of information. The term **Information and Communication Technology** (**ICT**) joins together: information, computers, computer science, computer engineering and communication. Last years ICT is growing very expansively, creates new great possibilities and gives us the new tools – which **we have to learn and creatively implement!** At the same time ICT creates new difficult tasks and challenges which are the reason for fears and horrors. It is because:

- Expansion of a new technology very often exceeds expectations, ideas and imaginations of a number of people;
- People observe a growth of science and technological progress with a fear and see there a source of the threat;
- A high level of unemployment, competition and environment devastation establish a food for fears;
- Some people are forced to change their jobs many times in their life;
- More and more people who cannot work all the life with a high activity fall behind;
- Globalization produces a high level of structural changes exceeding possibilities of many people;
- „High-Tech" comes easier to the regions with better educated staff;
- Generality, universality and necessity of continuous education – should have the highest priority level in Information Society.

One of the most important factors in a new concept of education is still a textbook. Thanks to the new ICT tools, the new version of textbook can be much more creative than previous one. Usually this kind of book is known as an "electronic book" (e-book).

II. ELECTRONIC BOOKS

According to the remarks pointed out in the first point, any book of the particular field of I&M can be prepared in electronic form and stored on CD-ROM (which can certainly be coupled with a traditional textbook). Certainly, the same content can be placed on the web sites, available via Internet. The electronic books have the advantage of presenting the extremely wide material on one CD. The cost of multiplying it is relatively low. Creation of the material can be done with the Dynamic HTML technology (HTML, Cascading Style Sheets, Java Script and FrontPage tools). Because of nearly unlimited space, besides a traditional content it can include:

- Set of publications and „source readings",
- Auxiliary software,
- Links to other knowledge sources: e-libraries, archives, collections,
- Questions/answers and auto-tests,
- Animations and simulations,
- Simulations of experiments,
- Links to real laboratories.

The material of an electronic book should be divided into three main parts [2]:

1. Introductory part,
2. Chapters,
3. Conclusions.

The **Introductory Part** should include:

- **Authors' note**, which describes book objectives. The authors explain what level of knowledge is expected from readers.
- **Requirements for computer** – includes description of requirements for computer.

- **How to use an electronic book** – it is clear, step-by-step instruction of how to use the material stored on the CD-ROM.

Each **Chapter** should include a series of basic parts that should be read in a suggested order. Every chapter is composed of several elements like:

- **Introduction,** which presents the aim of the particular chapter.
- **Paragraphs**, which include basic material (animations, simulations).
- **Auto-tests and problems**, this part includes examples of partly solved problems and tasks to be finished by the reader himself.
- **Glossary** includes new terms and definitions.
- **Bibliography** includes a list of important publications for further reading.

The content of **Conclusions** depends on the author and first of all should include directions for further readings and expectations as to the new trends in developments of the particular branch of I&M.

A proposed structure of the electronic book is presented in Figure1.

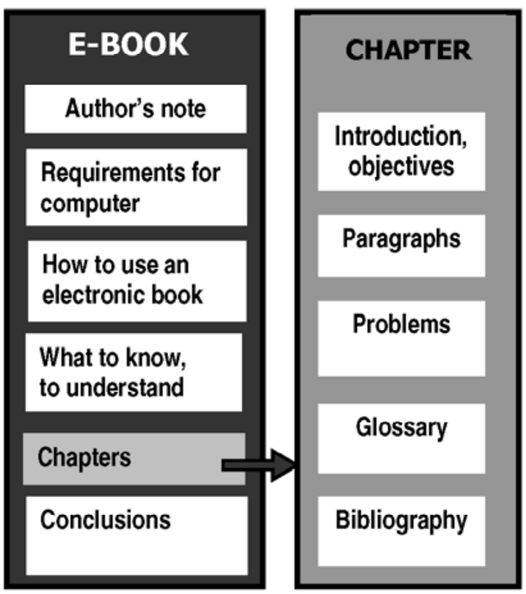

Fig. 1. Structure of the electronic book

The tools which can be implemented in the creation of an e-book, can be divided into three categories:

Traditional tools:

- Texts,
- Fonts: bold, italic, color etc.,
- Equations,
- Drawings,
- Photos,
- Background color, texture.

Multimedia tools:

- Text comments,
- Audio comments,
- Video comments,
- Animation of drawings,
- Animation of presentations.

Advanced tools:

- Generators of tests, „Local" simulations, „Distance" simulations,
- Simulated experiments,
- Remote experiments.

Addition tools compatible to HTML

- Java applets,
- FLASH modules.

Java programming language plays a very important role in preparing multimedia applications. It is a very useful tool in writing network applications. Java program can be run under any operation system. Java applets can be introduced into an HTML text of any e-book. They can it improve and animate. Simply, Java is able to enriched multimedia content of web sites throughout the animations, advanced graphic, sound and images with no any need for introducing additional applications available throughout the WWW viewer. A very complex program can be distributed throughout the polymorph network, Internet with no necessity of knowing what kind of operating system is used by the student. An example of Java applet is presented in Figure 2.

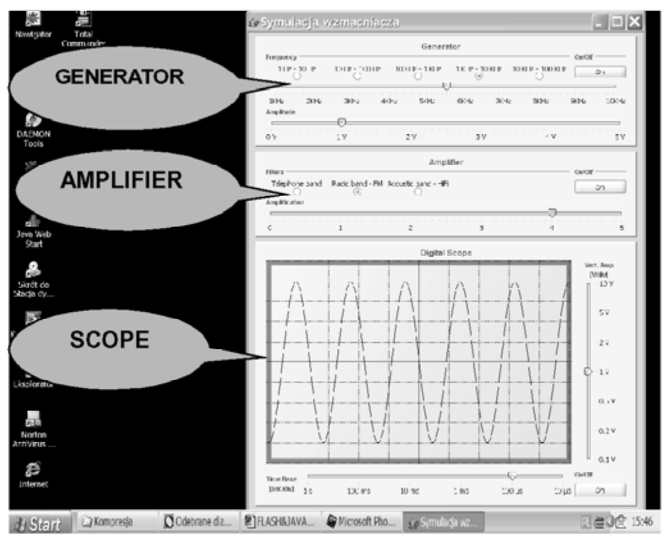

Fig. 2 The set of instruments prepared in Java applet form

Presented example of Java applet is prepared as a set of instruments connected together and creating a measurement system for investigating of an amplifier frequency response. We can change the amplifier frequency band from "telephone" to acoustic Hi-Fi. The frequency response can be investigated manually – what is certainly intentional.

The second, not less helpful tool in the area of animations destined to web sites, is **FLASH** from Macromedia. It generates small capacity files, acceptable by the all web sites viewers. The FLASH format, with "`.swf`" extension, is based on the vector graphic, where instead of keeping information about each image pixels, like in *bitmap*, there are used mathematical formulas describing shape, color and layout of the all object. Thanks to that, the created file has smaller capacity and even complex animations are lauded to the viewer very fast. The implementation of FLASH animation is a very simple process, available to everyone. An example is presented in Figure 3.

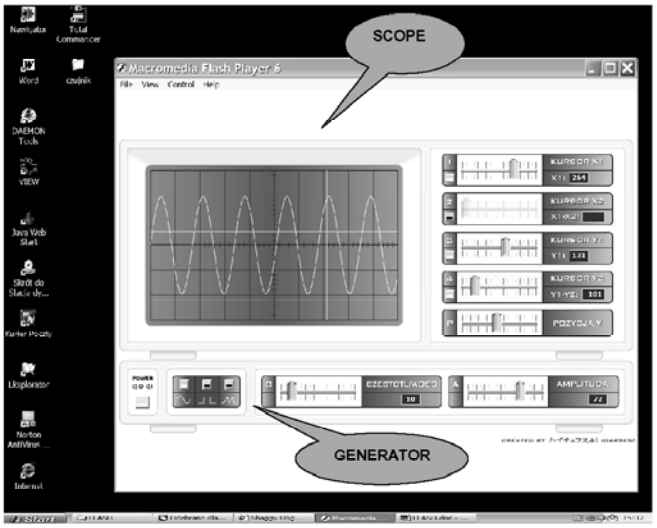

Fig. 3 An example of the FLASH animation module

On the monitor screen we can see two instruments: scope (on the top) and function generator (on the bottom). They are connected together. The output signal from generator can be seen on the scope display.

Simulations described above are strongly connected to the idea of **Virtual Instrument**.

III. THE IDEA OF VIRTUAL INSTRUMENT

Virtual Instrument can be described as a layer of software and/or hardware added to a general-purpose (personal) computer in such a fashion that user can interact with the computer as thought it were their own custom-designed traditional electronic instrument [6].

In order to construct a Virtual Instrument there is necessary to combine the hardware and software elements which should perform the data acquisition and control, data processing and data presentation in a different way to take maximum advantage of the PC.

The main, three categories of Virtual Instruments are presented below:

1. Computer controlling GPIB or RS232 instruments, with a graphical front panel on the computer screen to control the instrument;
2. Plug-in DAQ board or a VXI module instead of an external instrument, with a graphical front panel on the computer screen to control the instrument;
3. **Graphical front panel with no physical instruments at all connected to the computer. Instead, the computer acquires and analyzes data from files or from other computers on a network, or it may even calculate its data mathematically to simulate a physical process or event, rather then acquiring actual real world data.**

The 3rd category is that one which should be exposed in the design of electronic books. It simply let us to create virtual instruments, which can be fully placed on the CD. They can be prepared both, in HTML format or as typical Windows application.

The main idea of virtual instrument is presented in Figure 4 [5].

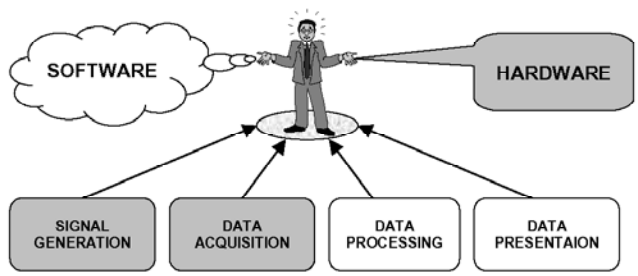

Fig. 4 The idea of a Virtual Instrument

Currently the most popular way of programming is based on the high-level tool software. With easy-to-use integrated development tools, design engineers can quickly create, configure and display measurements in user-friendly form, during product design and verification. The most known, popular software tolls are as follows: **LabVIEW** (National Instruments), **LabWindows/CVI** (National Instruments), **HP VEE** (Hewlett-Packard), **TestPoint** (Keithley). The power of the tool software lies in libraries. Library functions enable:

- Creation of Graphical User Interface **GUI** (Graphics Library, User Interface Library, Formatting and I/O Library),
- An access to instrument **Interfaces** (GPIB, RS-232, VXI, DAQ),
- Full control of autonomic **Instruments** (Instrument Library),
- Digital Signal Processing **DSP** (Advanced Analysis Library),
- An access to global computer network **INTERNET** (TCP/IP, DataSocket, ActiveX),
- Inter-process data exchange **DDE** (Dynamic Data Exchange).

A. Examples of Virtual Instruments:

Dual channel spectrum analyzer establishes a very impressive example of virtual instrument. The block diagram of spectrum analyzer designed especially for e-book reader is presented in Figure 5. It is realized as a kind of "**home version**" based on the personal computer equipped with typical ***Sound Board***. Nearly all types of the tool software are equipped with the functions servicing sound boards, which can be implemented instead of an expensive DAQ one.

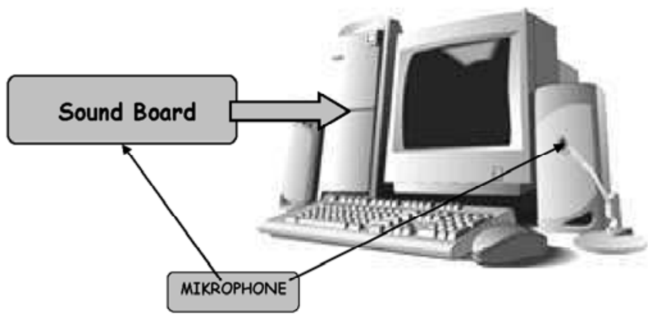

Fig. 5. Block diagram of spectrum analyzer based on Sound Board

In a case of DAQ implementation, the software part has been written under LabWindows/CVI environment, so that the graphical user interface (control panel) has a user-friendly form (Figure 6).

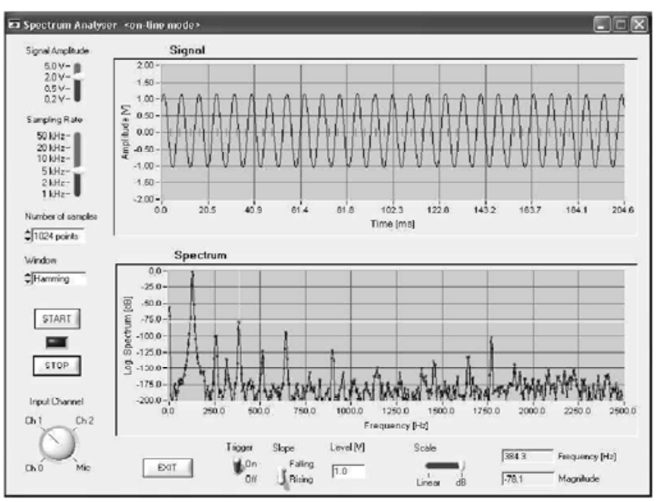

Fig. 6. Control panel of spectrum analyzer in on-line mode

An example (reconstruction) of the cooperated set of real instruments (arbitrary function generator: Agilent 33120A and digital multimeter: Agilent 34401A) prepared under LabWindows/CVI environment, is presented in Figure 7.

One of the most natural environments for virtual instruments implementation is distributed system, especially when we are taking into consideration the new, distance learning approach to laboratory training.

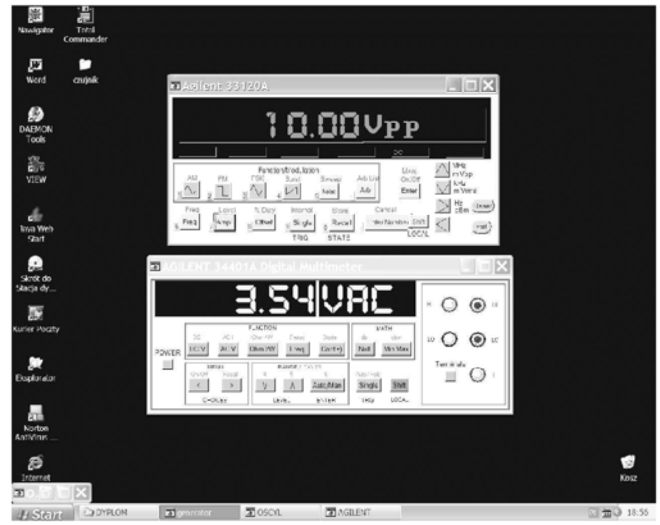

Fig. 7 The front panel of real instrument: function generator Agilent 33120A and digital multimeter Agilent 34401A.

IV. DISTRIBUTED SYSTEMS

At the present time LAN can be considered as a kind of measurement bus, from the viewpoint of measurement and control systems. It can be certainly extended to a wider, Internet based technology [4].

Common Internet-based software can be used to provide the easy of data migration between the various communication pathways. Multi-computer processing systems are effective in creating complex systems by overcoming the limitations of a single computer concerned with the overall computing power or the number of signals to be acquired and processed.

Standard software languages such as C and Java can be used with of-the-shelf development tools to implement the embedded network node applications and the web-based applications, respectively. Internet based TCP/IP protocols, Ethernet technology and/or DataSockets can be used to design the networking infrastructure.

DataSocket is a software technology for Windows that makes sharing all measurements across a network (remote Web and FTP sites) as easy as writing information to a file. It uses URLs to address data in the same way we use URL in a Web browser to specify Web pages. DataSocket included with any software tool is ideal when someone wants to complete control over the distribution of the measurements but do not want to learn the intricacies of the TCP/IP data transfer protocols.

In all types of networked and distributed measurement systems, presented above, real-time operation and constraints are critical issues to be considered during system design to ensure the correct system operation.

V. VIRTUAL LABORATORY

The critical element of testing theory through experiments cannot be missing in the e-book model. The missing link is the ability to carry out physical experiments over the web, fully integrated with other media for delivering e-book content, worldwide. In addition to simulating a virtual experiment, the reality of science and engineering can be learned better by remotely controlling an actual physical experiment. By supplementing e-book content with web-based experiments, the reader should be able to interact with physical systems, much in the same manner as modern experiments are carried out today, under computer control. Laboratories accessible from the Internet provide enrichment to the theoretical experience that is hard to obtain from other video based remote teaching methodologies. Remote control of experiments and equipment over the web is an idea that is just being strongly explored. Different tools are now becoming available for remote control of instrumentation using network communication. Several demonstrations of camera control and data acquisition as well as simple experiments have already been made [1][4]. Our knowledge concerning processes resulting from experiments, ability to control these processes and a set of tools needed for digital recording and transmission are good enough to introduce a new model of laboratory research – s.c. Virtual Laboratory. The most important elements of Virtual Laboratory are: Virtual Instruments and Distributed Measurement Systems. The idea of virtual laboratory is presented in Figure 8 [4].

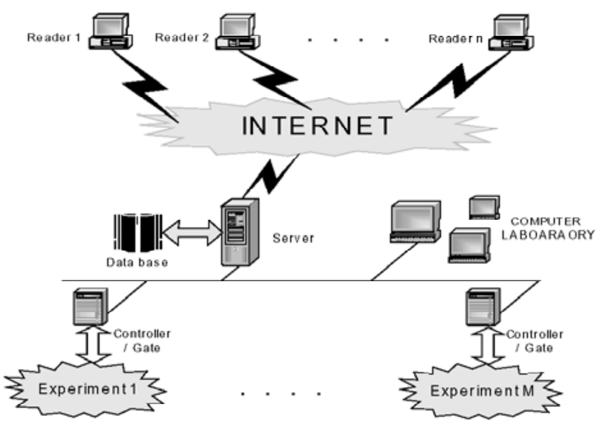

Fig. 8 The idea of Virtual Laboratory prepared for e-book readers

Let us imagine that some research center offers in a LAN some selected resources. All the e-book readers can have limited access to this environment. The resources can certainly be shared in much wider scale. It is very important in the case of a very specialized and expensive equipment.

The software destined to system supervision should implement the following tasks:

- communication process (between user and laboratory),
- access to laboratory resources (systems, instruments, functions),
- management over the laboratory resources (single instruments or groups),
- organization of the users (groups, rights to resources, rights under conditions, changes of rights, priorities),
- control over the single users and groups (authentication, authorization - rights),

The measurements can be realized in two modes: "on-demand" and "on-line". The first mode includes two separate cycles: *query cycle* and *answer cycle*. In on-line mode the user has a constant access to the instrument (on-line selection of functions and parameters, watching results).

Software, must include two main parts: server application, and client application. Each client includes control panel of virtual scope, prepared especially for tests running. The client can be attached to server - a gateway to real instruments. After login, there is opened a session for programming instruments and receiving measuring data. Additionally server plays a role of rights control, security carefulness and much more (concurrency of processes, multi-access).

VI. CONCLUSIONS

An important objective for the future in the area of Instrumentation and Measurement is an electronic book including multimedia tools and offering access to virtual laboratory, a very useful tool for teaching purposes in distance learning. Readers can run animation and simulation programs and even access virtual instruments via a geographic network and directly carry out real experiments by the using of a simple standard commercial Internet Web browser. In this way, a more complete educational proposal, can be offered by several laboratories specialized in different measuring fields. The remote laboratory concept allows measuring resources located at different geographically remote sites to be utilized by a wide distribution of readers.

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