System of Remote Access to the Dynamics Laboratory Resources over the Internet

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Abstract

The article presents a concept of *collaboratory* (virtual laboratory) realized in the Dynamics Laboratory. It was a second attempt to the project. Necessary communication and computer science technologies for remote MTS control are described.

Keywords

virtual laboratory system, material testing

Introduction

Today there are commonly known and used such ways of communication as e-mail, Usenet groups, WWW, video conferencing, online chats etc. None of them alone gives a possibility of engaging and active involvement in a real-time experiment. The idea of a laboratory available over a computer network to every one interested in appeared in the beginning of 90. In such a lab every interested scientist or student could take a part in an experiment. May observe and also control, change its conditions, share concepts and discuss the results right after they are achieved no matter where she or he resides (maybe the next room or another continent). [1]

The lab organized this way was called *collaboratory.* W.A. Wulf from the University of Virginia for the first time used the term *collaboratory.* It consists of two words: a verb *to collaborate* and a noun *a laboratory.* These two words express the spirit of the system: "Do science together without geographical barriers". [2]

In 1996 in the USA the Distributed, Collaboratory Experiment Environments DCEE program has started. "The goal of the DCEE program is to go beyond today's routine use of PCs and LANs in laboratory environments, and introduce a new paradigm more akin, perhaps, to virtual reality. The vision is for scientists that are scattered all over the country to get the same sense of

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presence and control (or even better) as if they were at the scientific experiment site." [4]

Concepts stated in [4] become an inspiration of starting the first project of the virtual laboratory. It's specified in [2]. Results encouraged trying the second attempt with more advanced Internet integration of the system.

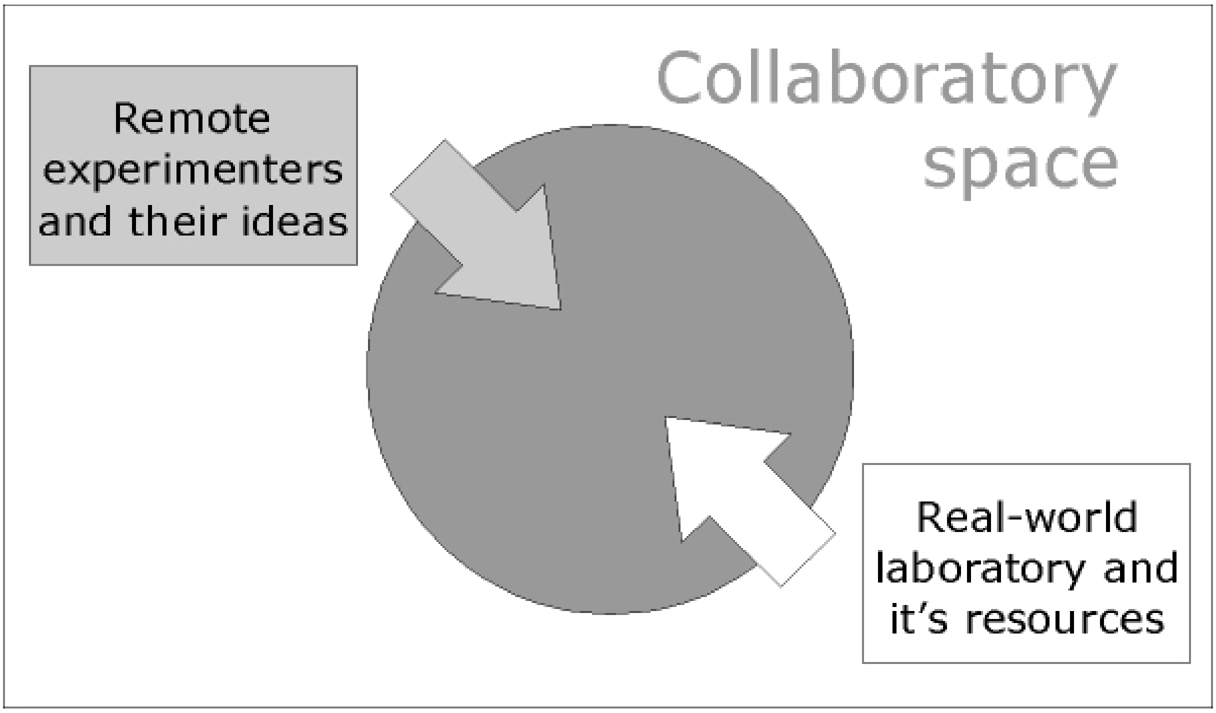

Fig. 1. The virtual laboratory idea

Fig. 1 shows the basic idea of the virtual laboratory. In the lower-right box we have a real-world lab resources (people: staff, experimenters; equipment; research objects). In the upper-left box we have remote experimenters (scientists, students) with their knowledge. All they meet in collaboratory space created by means of telecommunication and computer science i.e.: network framework, computer devices, software etc.

Description of the System

Author realized the idea of the collaboratory in the Dynamics Laboratory in the Institute of Material Science and Applied Mechanics at Wroc³aw University of Technology. The virtual laboratory system is available during an experiment at: http://vlab.immt.pwr.wroc.pl .

While no experiments are on the run it is possible to make simple real-time temperature measurements outside and inside the Institute building or retrieve temperature records data from database updated every half an hour for over 3 years.

Before the system was built following assumptions had been made:

- hardware part of the system should base on existing infrastructure of the Dynamics Laboratory i.e.: computers, network, material test system and measuring equipment;
- software part should be independent on hardware platforms and work as well under UNIX as Windows operating systems;
- if it's possible open source software should be used.

Hydraulic pulser (MTS-810) installed in the Dynamics Laboratory is used for cyclic loads material testing, crack mechanics experiments or vibration damping experiments. It has 10kN max load and 100Hz max pulsing frequency. Constraints could be given manually from a Micro Profiler – a kind of control device. Constraints may be also remotely programmed and written in Micro Profiler's memory. Special instructions set must be used.

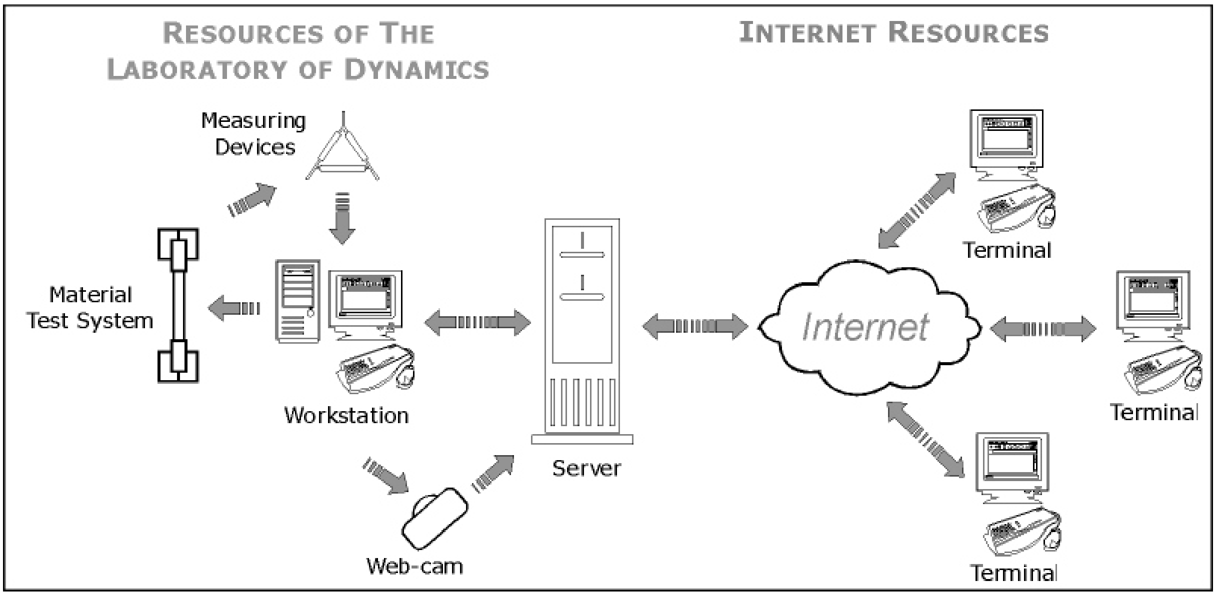

Fig. 2. The virtual laboratory key components and communication scheme [6]

If we want, for example, to constrain a sinusoidal load on a specimen, we need to construct a waveform with following instructions: nK, nH where n is an integer number (for K greater then 0). K command sets frequency, H command sets the level (amplitude) of our waveform. When command J is sent program is executed.

MTS-810 (by it's Micro Profiler) is connected to the workstation via RS-232 port so remote commands may be sent. Measuring devices are connected by 16-channel measuring card. On the workstation (with Celeron 800MHz processor and Windows NT OS) runs dedicated software application made in Hewlett-Packard VEE 5 environment. It receives steering commands from the remote user and sends them to the Micro Profiler, which translates them into current values (fig. 2). Basing on these values MTS carries appropriate forces or displacements into effect. Measuring devices send recorded values to the VEE application that gathers experimental data and transfer them as graphic files to the server. Of course it's possible to send ASCII files with results, but for a long time experiments ASCII files dangerously grow on size and may chock the network connection.

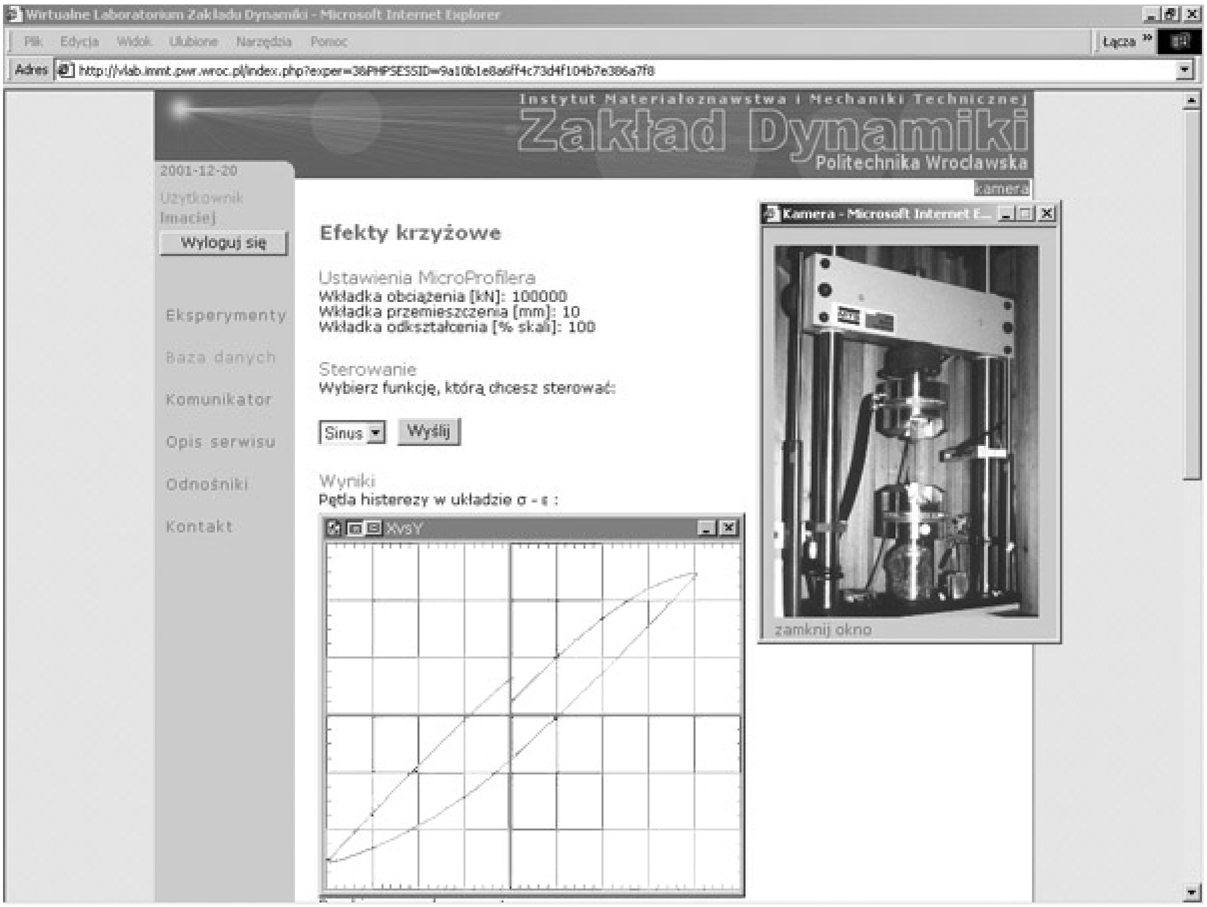

Fig. 3. View of the virtual laboratory web site during a cross effect experiment

Lets take a look at the Internet resources side. Experimental results are sent via SAMBA application from the workstation to the server. Then results are dynamically included to the web service. Once they appear on the web site, every one interested and logged in may easily access them (fig. 3). How does it happen? On the server PHP module is installed. PHP is a kind of scripting language with C-based syntax designed specially for dynamic and interactive web sites creation. According to the script code PHP engine generates HTML documents that are served for the Internet users by a WWW server. [5] PHP provides user-dependent content building possibility. In our virtual laboratory users may take part in an experiment at three levels:

- just beholders observing results,
- beholders with an access to communication application written in Java,

- experimenters with full access to communication and control applications.

User information is stored in database and checked every time one wants to log in. To secure the system without logging only the description and links base are served.

Experiments

Basing on [3], [7] and [8] the author worked out an experiment of termomechnical (Kelvin's phenomena) and magnetomechanical (Villarie's phenomena) cross effects in a ferritic steel specimen under cyclic loads. Kelvin's phenomenon is noticed in metals during an elastic strain at adiabatic conditions. While a metal specimen is being stretched it's temperature lowers and while compressed its temperature grows. Villarie's phenomenon, known also as reverse magnetostriction phenomenon that is observed in metals while under loads they emit magnetic field. Detailed descriptions of above are in [3] and [8].

In the experiment a cyclic load of sinusoidal characteristic (1Hz frequency) was borne on St3 steel specimen. The strain amplitude was remotely changed from 1% up to 8% while the specimen reached the plastic state.

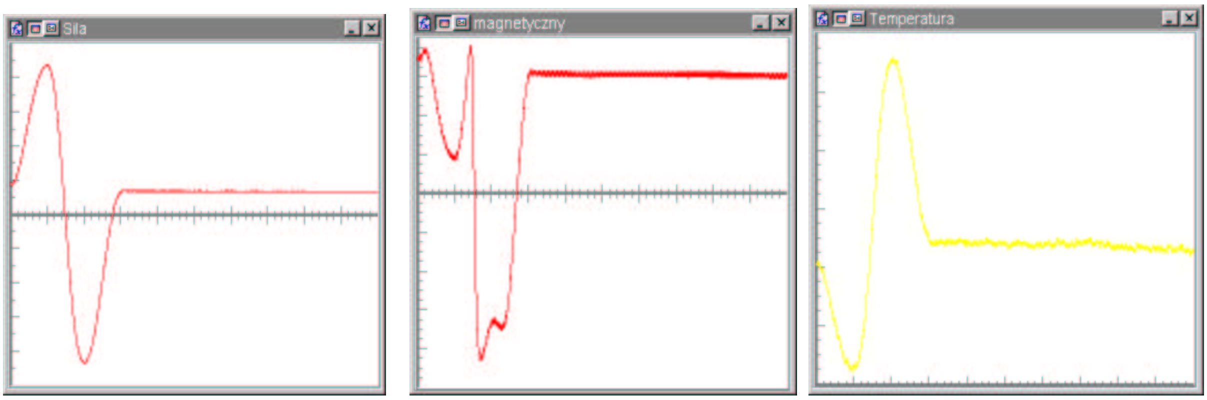

Fig. 4. Results observed in the collaboratory, from the left: load, magnetic field intensity and temperature change signals measured in a ferritic specimen.

Stress $\sigma(\xi)$, strain $\varepsilon(\xi)$, temperature $\Delta T(\xi)$ and magnetic field intensity $H(\xi)$ signals were recorded (fig. 4). J type thermocouples with the diameter of 0.25 mm and 0.001°C grain measured temperature. Magnetic field intensity was recorded with type KMZ51, measuring range up to 520 A/m and grain of 0.01A/m magnetoresistor.

The experiment was remotely controlled via the Internet. Of course a steel specimen and measuring appliances had to be mounted by the laboratory staff.

Magnetoreological fluid damper experiment is under construction. For remote control and access the same collaboratory environment will be used. More about could be found in [7].

Conclusions

Computer science and telecommunication technologies development make it possible to realize the idea of the virtual laboratory in distributed scientific environment nowadays, especially when unique or expensive research equipment is used.

The second attempt to the virtual laboratory was successfully implemented in Laboratory of Dynamics in the Institute of Material Science and Applied Mechanics at Wroc³aw University of Technology. There were several experiments led with groups of students. They had a chance to take a part in a real experiment on a real specimen, sitting comfortably in a computer lab. Geographical distance to the real lab was unimportant as all necessary results and steering possibilities were delivered to the group through the Internet.

Of course the system needs further development. Communication between local and remote experimenter must be faster and give if not a real, maybe just a contact makeshift. Instant messaging or videoconferencing software delivered with modern operating systems may be used.

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