From Real World Experiment to Virtual Laboratory And Next Generation Grid

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Abstract- *The Grid technologies are introduced to build e-Learning environments for engineering education. Service-oriented Grids open new fields of applications, the Learning Grids. The learning services concept based on a learning model and their deployment through Grid technologies are excellent means to integrate virtual laboratories into e-Learning environments for engineering education. The paper goes into the most important technical details, introduces into the used learning model, and shows the authoring of Grid resources for virtual laboratories. Examples from a virtual laboratory demonstrate the advantages of a Grid.*

Keywords*: Learning systems, Grid, data transmission, virtual instrumentation*

I. INTRODUCTION

Remote or virtual laboratories with real or simulated experiments are becoming accepted in the engineering community for providing distance education and for augmenting traditional laboratories. Students have to modify instruments for a better understanding of the principle on which the plant operates. They even have to set their own conditions. From a pedagogical point of view, in this kind of environments the student has an active and central role in the learning process. Learning activities are inherently aimed at aiding the construction of knowledge and skills in the student, rather than the memorization of information. In keeping the student at the centre of the learning process, personalization and individualization become relevant aspects to be supported by technologies through the creation of the right context. The students can learn through direct experiences. So, the question remains – how do we provide better means for e-Learning environments combined with virtual laboratories while maintaining or improving the quality of learning by new information and communication technologies. A Learning Grid can contribute to the achievement of these objectives through the definition of the learning services concept and their deployment through Grid technologies.
Historically the term Grid has been used describing a worldwide communication infrastructure for clustered computers that allows seamless transparent access to data and computing power on demand in order to solve large-scale computational problems. Such computing Grids cost a fraction of what a supercomputer costs. They are commonly known from engineering, science and commerce. Grid is also a new paradigm for the information technology. The well known World Wide Web will be succeeded by the upcoming World Wide Grid. The futurologists are promising that it will be possible to get large IT-resources "from a plug in the wall" without the necessity to know who provides the resources and where the resources are coming from. Nowadays such service-oriented Grids find applications in quite new areas not previously considered as the environments for a Grid. An example of such a new area is education.

II. GRIDS IN E-LEARNING

Grids yield significant benefits to applications. a Grid is considered as a collection of clustered computational machines, the nodes. In order to have a powerful supercomputer by a Grid the computational problem has to be split into slices and assigned to these nodes. Each node processes its slice individually and after the completion of its slice the results are put back together. Grid nodes do not need to be placed in one geographic location; moreover, machines collaborating in the Grid may have different architectures and operating systems. It is obvious that these nodes need to communicate with each other based on some standards. Therefore a vital topic of security is involved for the interchange of data between nodes.

Depending on the application the data should be kept confidential and protected from undesired external changes. Also other issues must be addressed, e.g. redundancy of nodes, quality of service and scalability.
The Grid is applicable only for tasks that can be easily split into smaller slices and that do not require the characteristics of a real-time challenge. In order to reduce the complexity of a Grid, a special layer is introduced that is for gluing the nodes on a logical level. This layer of software sandwiched between the operating system and the applications is commonly called middleware. During recent years a new approach for building Grids has emerged. Instead of perceiving the Grid nodes only as computational elements of an infrastructure they became providers of services. This shift, from strict computational capabilities to service suppliers, opens new fields of applications for Grids. The nodes, instead of only delivering their computational and storage capacity, are now regarded as providers of particular services. They may be parts of some code existing in multiple instances allowing the parallelization of the execution of an application. This new Grid philosophy allows perceiving it in analogy to the commonly known concept of power grids, where the consumer is not aware where and how the power is exactly produced. The consumer only receives the final product with a defined quality.

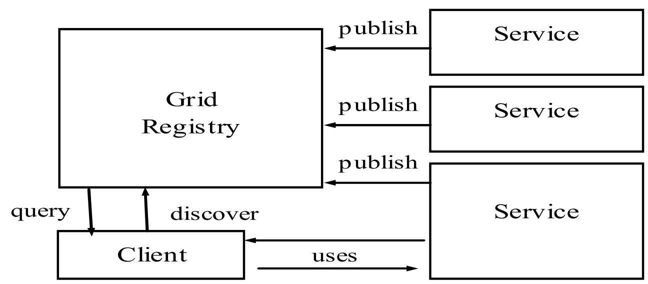

Fig.1. Structure of a service-oriented Grid environment.

Figure 1 presents basic interactions between elements of a service-oriented Grid. Services published into a Grid Registry are queried and when discovered then instantiated depending on the user request. Mainly for sake of efficiency the client's communication with the service is direct but may also be virtualized. The main functionalities delivered by the middleware of a service-oriented Grid are:

- Location – allows the determination, whether the required service exists and at which locations it is accessible
- Instantiation – allows the instantiation of the service on that host, which matches the capabilities required for the service running with a given quality of service.
- Orchestration – allows the dynamical composition of more complex services.

III. VIRTUAL LABORATORY - SYSTEM ARCHITECTURE

The main objective of this work is to realize a complex device for environmental quality monitoring based on specialized sensors that are connected in a unit system. This device is very useful in the new society information to create a Virtual Laboratory for a remote teaching. That means the students will be able to perform the lab work, controlling the applications and accessing the virtual library. The low-cost availability of new communication tools based on Internet is opening more and more horizons to remote teaching. Interactive on-line tutorials based on World Wide Web (WWW) sites now can be followed directly on the web site. The hardware of environmental quality monitoring systems (sensors, conditioning circuits, acquisition and communication) must usually be complemented with processing blocks to perform different tasks associated to one-dimensional or multi-dimensional data that flow on the system measurement channels.
The architecture is composed as follows: the specialized sensors, detection circuit, a prototype data acquisition board by parallel port, PC-host, the server provided with an Ethernet controller as shown in figure 2. Using all this hardware we are able to perform a study for Taguchi-type gas sensors.
The authors propose in the same time an educational measurement remote system. In this way, two parts compose the architecture of the system: client user that uses a client computer and measurement provider who disposes the server with the web site of the virtual laboratory.

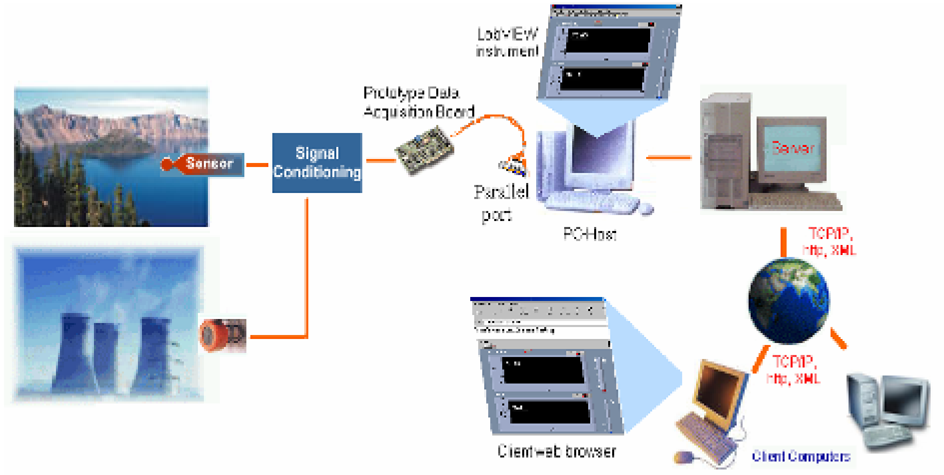

Fig.2. The system for on-line environmental monitoring using a prototype data acquisition board.

Number of students connected in the same time is unlimited. All communication software is designed under LabVIEW graphical programming language.
In the figure 3 is presented the main web page of application. The main web page is located in server that allows the access to every station, using a connection link.
In this machine a web server is run. The LabVIEW server represents the back up for the individual stations.

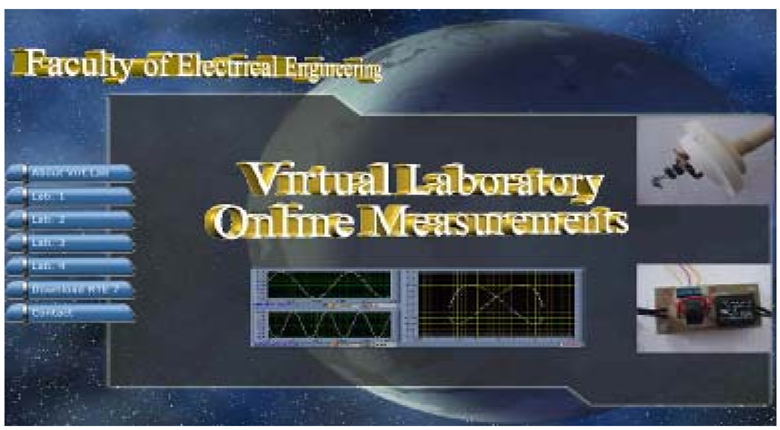

Fig.3. The system for on-line environmental monitoring using a prototype data acquisition board.

An adaptive architecture based on web server application is proposed, in order to increase the performance of the server that hosts a dedicated Web site, and customize the Web site in a manner that emphasizes the interests of the clients. The most virtual laboratories normally provide access either to one remote application, or accept only one user at a time. The system presented below provide a multitask connection, with possible variants for remote education (figure 1). We have developed two possibilities to have classes in this virtual laboratory:

1. In the first case, a tutor can teach all students connected to the local server at the same time, by setting the server to all users slave mode. The locations and number of users to be connected in the same time is practically unlimited.
2. In the second case, the server is set to all user masters, and the students can perform individually the connection via modem in order to train and/or practice the programs.

Due to a multitask facility, number of users connected in the same time is also unlimited.
The instrumentation control and communication software has been designed under LabView graphical programming language.

In particular, the PC-server – via TCP/IP protocol and the client-server - via CGI (Common Gateway Interface) technology, have developed the PC-instruments communication. CGI simply defined an interface protocol by which the server communicates with the applications, and a dedicated software package supported CGI applications in form of virtual instruments, used to develop interactive applications for Web-enabled experimental set-ups. The following procedures are implemented on laboratory server: dynamically allocation, web interfaces and Slab-SL interface. The communications between Lab server and each workstation are performed by bi-directional interfaces SL-Slab and Slab-SL. In the front panel of application, the setup parameters are performed, and data are transferred to e-multitask interface. From the main web page of the laboratory server, the teacher/tutor has the possibility to supervise directly and selectively the student’s activity.

IV. THE REAL WORLD EXPERIMENT SYSTEM

IV. 1. Data acquisition board

The data acquisition system is a low cost board realized around the chip LM12H458 that is an integrated DAS and offers a self-calibrating 12-bit a sign A/D converter with choice of single ended, fully differential, or mixed inputs, with on-chip differential reference, 8-input analog multiplexer, sample-and-hold, an impressive, flexible programmable logic system and a choice of speed/power combinations. The programmable logic has the circuitry to perform a number of tasks on its own, freeing the host processor for other tasks. The board can be used to develop both software and hardware. Since the parallel port is limited to 8-bit bidirectional data transfers, the BW pin is tied high for 8-bit access. Multiplexed address/data bus architecture between the DAS and LPT is used. Digital and analog supply pins are connected together to the same supply voltage but they need separate, multiple bypass capacitors. Multiple capacitors on the supply pins and the reference inputs ensure a low impedance bypass path over a wide frequency range. All digital interface control signals (/RD, /WR, ALE, /INT, /CS), data lines (DB0–DB7), address lines (A0–A4) connections are made through the motherboard LPT connector using a standard LPT cable. All analog signals applied to, or received by, the input multiplexer (IN0–IN7), VREF+, VREF−, VREFOUT, and the SYNC signal input/ output are applied through a connector on the rear side of the board. Because the LM12H458 is so versatile, working with them may appear to be an overwhelming task. However, gaining a basic understanding of the device will prove to be fairly easy and using it to be as easy as programming the host microprocessor or microcontroller.
The main features of our DAQB are: 4 full-differential channels, 12 + sign ADC resolution, 100 ksamples acquisition rate, 20 ksamples transfer rate, 1 LSB linearity, 0,5 LSB accuracy, auto-zero and full calibration procedures, ± 5V input voltage span, 30 mW power dissipation.

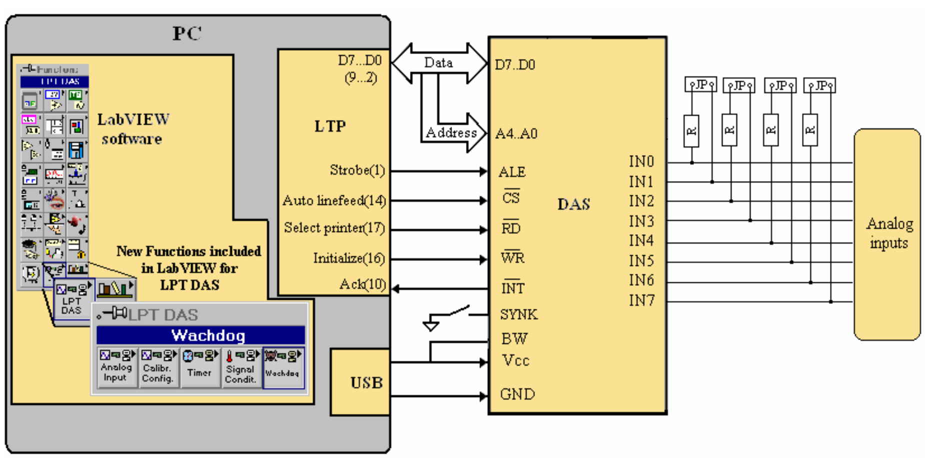

Fig.4. The Virtual library and the architecture of data acquisition system.

In Table 1 we present the obtained results using the new LPT-DAQB and different apparatus.

Nr.	**GEN DC** [V]	**LPT-DAQB** [V]	**KEITHLEY 2000** [V]	**METERMAN 38XR** [V]
1	0.010	0.0117	0.0116	0.0114
2	0.020	0.0218	0.0216	0.0213
3	0.040	0.0425	0.0418	0.0414
4	0.060	0.0621	0.0618	0.0615
5	0.080	0.0825	0.0819	0.0816
6	0.100	0.0102	0.1018	0.1015
7	0.500	0.0505	0.5036	0.5034
8	1.000	1.0100	1.0060	1,0020
9	1.500	1.5130	1.5070	1,5040
10	1.700	1.7150	1.7080	1,7050
11	2.000	2.0180	2.0090	2,0060
12	2.200	2.2190	2.2100	2,2070
13	2.400	2.4220	2.4110	2,4070
14	2.500	2.4994	2.5120	2,5090

Table 1. Comparative measurement.

DAQB presented have the capability to perform tasks that diminish the host processor work and is capable to communicate with the host computer by using a set of drivers associated in LabVIEW software. The novelty of our work mostly consists in the drivers and functions associated that are gathered into a library easily accessed by LabVIEW and assure the flexibility and the portability of the system. One of the performances consist in the fact that you can plug-in the DAQB to the running host computer externally.

IV. 1. Sensor module

The sensing element is a metal oxide semiconductor mainly composed of SnO2. This element is heated at a suitable operating temperature by a built-in heater. Exposure of the sensor to a vapor produces a large change in its electrical resistance. In fresh air the sensor resistance is high. When a combustible gas such as propane, methane etc. comes in contact with the sensor surface, the sensor resistance decreases in accordance with the present gas concentration. Recently, new methods have been proposed for chemical sensing that utilizes the analysis of the stochastic component of the sensor signal in Taguchi type sensors. It has been shown that even a single sensor may be sufficient for realizing a powerful electronic nose. However, there are no studies of the power spectrum in different types of commercial gas sensors under different gas atmospheres. This paper studies the stochastic signal in commercial semiconductor gas sensors measured under different atmospheres.

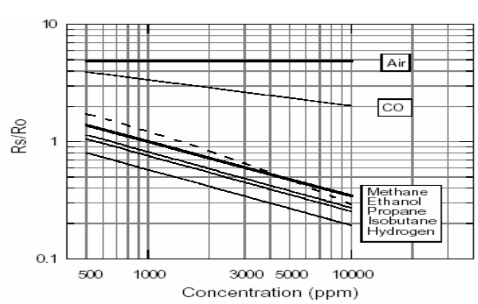

Fig.5. Sensitivity characteristics.

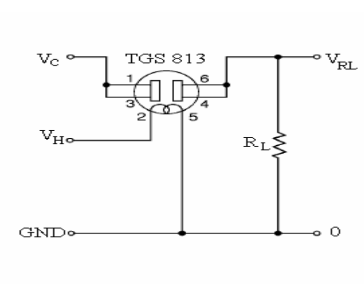

Fig.6. Detection circuit.

Figure 6 shows the basic detection circuit. The change in the sensor resistance is obtained as the change of the output voltage across the load resistor (RL) in series whit the sensor resistance (RS). The constant 5V output of the data acquisition board is available for the heater of the sensor (VH) and for the detecting circuit (VC).

IV. CONCLUSIONS

Learning Grids contribute to the achievement of the objectives given in the introductory chapter to this article through the definition of the learning services concept and their deployment through Grid technologies. Learning services will be consumed in dynamic virtual communities based on communications and collaborations where learners, through direct experiences, create and share their knowledge in a contextualized and personalized way.

This way of learning using grid resources can become now more open to learners in the engineering domain. The application of Grid technologies in education is of course a much wider topic than presented in this article and by the practical example of a virtual control laboratory. Nonetheless the most important aspects of utilizing service-oriented Grids in distance learning for control education are presented.

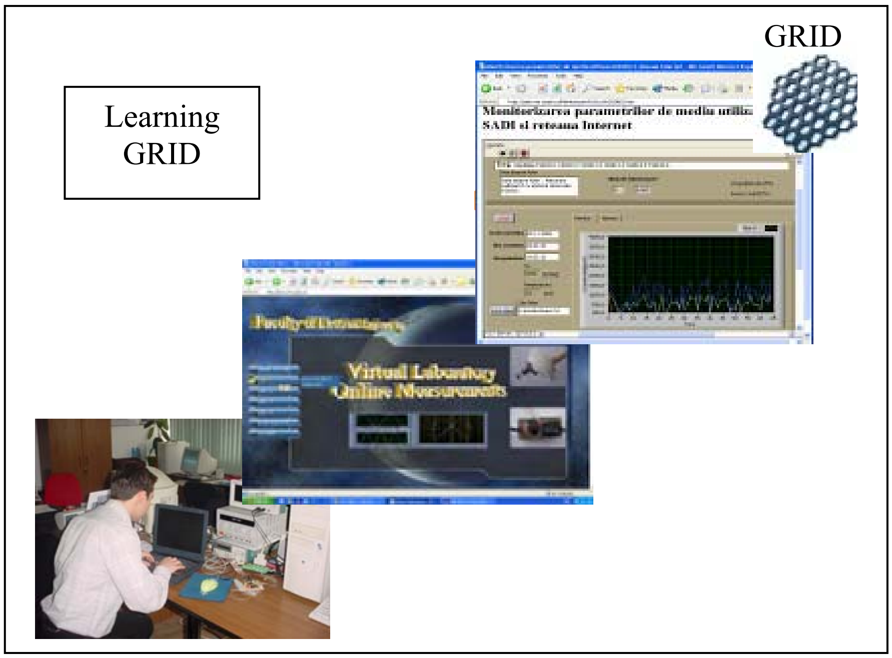

Fig.7. From real world experiments to Grid environment through Virtual Laboratory

References

[1] http://en.wikipedia.org/

[2] The Global Grid Forum. Available: http://www .gridforum.org

[3] The Web Service Resource Framework and Microsoft .NET technologies, University of Virginia. Available: http://www.cs.virginia. edu/~gsw2c/wsrf.net.html

[4] www.ni.com – Solutions

[5] National Instruments, Measurement and Automation Catalogue, 2004

[6] National Instruments, LabVIEW User Manual and G Programming, 2001

[7] M.Branzila and Co., Virtual Library Included in LabVIEW Environment for a New DAS with Data Transfer by LPT, IMEKO 2005 - 14th International Symposium on New Technologies in Measurement and Instrumentation and 10th Workshop on ADC Modelling and Testing, 12-15 September 2005, Gdynia/Jurata Poland, ISBN 83-89786-37-0, pag.535-540

[8] M.Branzila and Co, System for Environmental Monitoring Using a Data Acquisition Board by Parallel Port BULETINUL INSTITUTULUI POLITEHNIC IAŞI TOMUL XLVIII (LII), FASC. 5, 2004.