

# Italian-Croatian Remote Laboratory Distributed on Geographical Network

Mladen Borsic<sup>1</sup>, Drago Cmk<sup>1</sup>, Pasquale Daponte<sup>2</sup>, Claudio De Capua<sup>3</sup>, Domenico Grimaldi<sup>4</sup>,  
Tomislav Kilic<sup>5</sup>, Tarik Mutapčić<sup>6</sup>, Mariella Riccio<sup>7</sup>

<sup>1</sup> Faculty of Electrical Engineering and Computing, Zagreb, Croatia

<sup>2</sup> Department of Engineering, University of Sannio, Corso Garibaldi, 107, 82100, Benevento, Italy

<sup>3</sup> Dip. Informatica, Matematica, Elettronica e Trasporti, University "Mediterranea", Reggio Calabria, Italy

<sup>4</sup> Department of Electronics, Computer and System Science, University of Calabria, Rende-CS, Italy

<sup>5</sup> Faculty of Electrical Eng., Mechanical Eng. and Naval Architecture  
University of Split, Split, Croatia

<sup>6</sup> Tarmel d.o.o., Obrtnicka 11, Sveta Nedjelja, Zagreb, Croatia

<sup>7</sup> Didagroup SpA, Via dei Sanniti, 1 – 82018 S. Giorgio del Sannio (BN)

**Abstract:** The paper presents the E-learning project and the work until now done to extend the features of the Italian Remote Laboratory "G.Savastano" to the academic circles of East Europe, Western Balkan and Mediterranean area. In particular, in the framework of the project "Italian-Croatian Remote Laboratory Distributed on Geographic Network", the Italian-Croatian collaboration is highlighted. The proposed approach follows EU efforts to implement internal Lifelong Learning Program and influence educational systems of EU partner and neighbor Countries while helping them to overcome problems with their own educational systems and lack of resources. Developed experiments give the possibility of achieving practical experience on several fields, while multilingual approach gives the access to such facility to the students coming from different Countries. Moreover, the idea of interactively controlled transfer of knowledge and experience offers a new dimension to the remote experiments enabling them to be executed without supervising necessity.

## 1. INTRODUCTION

The education reform and research investment strategies are some of the most important aspects of European Union (EU) strategic plan for 2005-2009 [1]. As a matter of fact, European Community Lisbon Program declares: "Europe will need to invest more in its young people, education, research and innovation, so that we can provide our society with the assets and outlook to generate wealth and provide security for every citizen" [2]. Some of the most important goals for next few years are creating the European Research Area, development of Internet based education and training as a part of a Lifelong Learning Program and others. Particularly, recognizing the advantages of Internet based facilities several programs, initiatives and projects have been founded by EU Commission (7<sup>th</sup> RTD, i2010, the most recent Framework 6 etc.). Due to the wide political and social transformation in East Europe, Western Balkan and Mediterranean area, there is increasing need for new teaching approaches similar to European one. European Commission established European Training Foundation (ETF) which mission is to assist partner Countries in developing quality education and training systems and in putting them into practice. Each year, the ETF work program is structured around a series of projects (TEMPUS, SEE, MEDA, EECA, etc.) which take place in the partner Countries to facilitate the reform of vocational education and training and employment systems. Approach

proposed in this paper could be used to spread this novel and accepted education approach in mentioned Countries [3].

When speaking about education in technical areas practical experience is a step of crucial significance when comes to placing a theoretical knowledge in work. Especially in teaching electric and electronic measurement topics, this kind of experience should be given to the learners through laboratory work. However, due to expensive equipment, necessity for repeating the same experiment many times (because of a big number of students) and insufficient number of qualified teaching personnel, electric and electronic laboratories for didactic purposes are difficult to set-up. Moreover, some faculties across different Countries are unable to deal with mentioned problems mainly due to the lack of financial support.

E-learning seems to be the best way to reach these objectives, as it removes the physical, geographical and cultural barriers to the education and enables the learners in choosing their own learning path and time. Laboratory activity is an open challenge for on-line teaching applied to scientific domains. The remote control of instrumentation and the execution of real experiments via Internet are topics of interest for many researchers [4-7].

Regarding remote measurement laboratory as a Distributed Measurement System (DMS) with some simplifications deriving from the specific requisites of distance learning a distance learning laboratory has been developed at the University of Sannio in Benevento, Italy. It includes the features of a complete Learning Management System (LMS) with experiments on actual electronic measurement instrumentation [8].

In this framework, University of Sannio is currently developing common projects with Croatia, Greece, Slovakia and Ukraine [9]. In particular, the project "Italian-Croatian Remote Laboratory Distributed on Geographic Network" was submitted to the Call "Programmi per l'Incentivazione del Processo di Internazionalizzazione del Sistema Universitario (D.M. 5 agosto 2004 n. 262 - ART. 23) Collaborazioni Interuniversitarie Internazionali - Programmazione 2004-2006" and supported by the Italian Ministry of Education and University. Project partners are University of Zagreb, University of Split, TARMEL company (Zagreb), University "Mediterranea" of Reggio Calabria, University of Calabria, and University of Sannio [10].

The paper deals with the state of art of this collaboration. After a description of the Italian-Croatian collaboration, the

software and hardware solutions adopted for the remote measurement laboratory are illustrated. Then, some operative examples are given with the aim to highlight the potential applications of the developed system.

## 2. THE ITALIAN-CROATIAN COLLABORATION

The project “Italian-Croatian Remote Laboratory Distributed on Geographic Network” is the last step of a deep and fruitful collaboration among some Italian and Croatian Institutions.

Croatian teachers were Visiting Professors at University of Sannio, and Italian teachers collaborated with Croatian colleagues for the organization of International events held in Croatia. It is worth to note the official sponsorship of University of Sannio to the XVII IMEKO World Congress *Metrology in the 3<sup>rd</sup> Millennium* held in Cavtat (Croatia). Some official agreements were signed among Italian and Croatian Public Institutions [11].

A Croatian researcher was the coordinator of the Italian-Croatian project “*Estimation of the uncertainty in measurement of the electric energy*” founded by Italian Ministry of Education and University. The project, three years long, was carried out in collaboration with Croatian Electricity Utility. This Company gave the possibility to perform in situ measurements on high-voltage transmission line [12, 13].

Furthermore, the “Italian-Croatian Research Doctorate in Information Technology” was established. It is an action included in the *Memorandum of Understanding* for the international co-operation between the University of Zagreb and the University of Sannio. Rectors of both Universities nominated the Joint Italian-Croatian Commission for Doctorates [14].

## 3. THE PROJECT “ITALIAN-CROATIAN REMOTE LABORATORY DISTRIBUTED ON GEOGRAPHIC NETWORK”

### 3.1 Objectives

The main aims of the Project “Italian-Croatian Remote Laboratory Distributed on Geographic Network” [10] are (i) building the capacity of faculty members and staff, (ii) developing curriculum, and (iii) preparing the Universities to launch a state-of-the-art programme in remote laboratory facilities.

The following main objectives will be pursued:

- develop E-content for electrical engineering, information technology, and computer science university courses and to implement new teaching methodologies;
- design, implement and introduce remote laboratories into engineering and information technology curricula;
- introduce an E-learning initiative and remote laboratory facilities to universities in Western Balkan Countries;

- lay out a strategy and an implementation plan for supporting higher education institutions to develop and embed E-learning and remote laboratories;
- build the capacity of university professors by providing training and consultation for website interactive teaching, blended learning, and E-learning;
- act as a platform for technology and know-how transfer by sharing knowledge with EU partners;
- improve the quality of E-learning, based on the utilization of standards;
- provide training and tutoring for staff and students;
- organizing conferences, workshops, tutorials, seminars and exhibitions in relevant fields.

### 3.2. Laboratorio Didattico Remoto – LA.DI.RE. “G. Savastano”

The activities of project “Italian-Croatian Remote Laboratory Distributed on Geographic Network” are possible thank to the results of a previous project financed by the Italian Ministry of Education and University within the National Operating Programme (PON) 2000-2006 [15] giving the possibility to University of Sannio to set-up a learning environment, called *Laboratorio Didattico Remoto – LA.DI.RE. “G. Savastano”* (Remote Didactic Laboratory), dedicated to the memory of Prof. G.Savastano. The home page is shown in Fig.1. The web address is: <http://www.misureremote.unisannio.it>.

This measurement laboratory provides the students of electric and electronic measurement courses with the access to remote measurement laboratories delivering different didactic activities related to measurement experiments.

With the introduction of this measurement laboratory a further step in the E-learning evolution was introduced (Fig.2).

The initial infrastructure is composed of the laboratories at the University of Sannio and at the University of Reggio Calabria “Mediterranea” under the patronage of the National

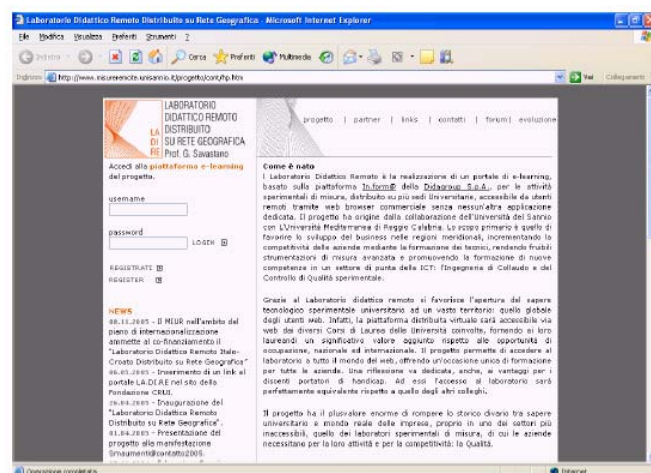


Figure 1 – Home page of the Remote Didactic Laboratory LA.DI.RE. “G. Savastano”.

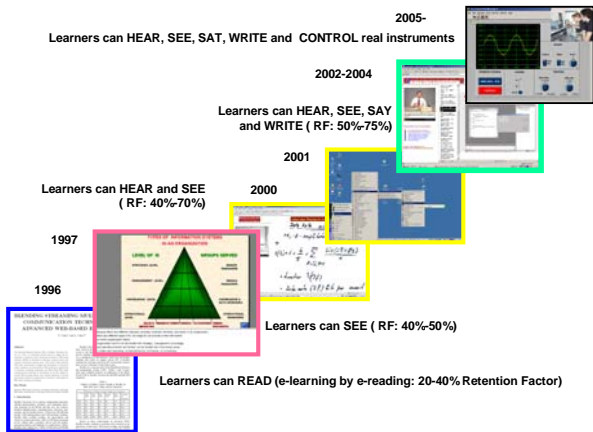


Figure 2 - E-learning evolution with the introduction of the remote measurement laboratories.

Research Association on Electric and Electronic Measurement (GMEE), and the collaboration of about twenty Italian universities and some specialized instrumentation, e-learning and publishing companies such as National Instruments, Tektronix, Agilent Technologies, Yokogawa, Keithley, Rockwell Automation, Didagroup, Augusta publishing.

Moreover, the work carried out until now led to a second project, financed by the Italian Space Agency, aiming to design a satellite-based distance learning system [16].

### 3.2.1 Hardware and the software components of LA.DI.RE. "G. Savastano"

The hardware and the software components of LA.DI.RE. "G. Savastano" are shown in Fig.3 and Fig.4, respectively.

In order to allow the the student to access the remote and geographically distributed didactic laboratory, the web-based multi-tier distributed architecture is implemented centered on the LMS that can be considered as the core component of the overall system [8]. The proposed multi-tier architecture is composed of three tiers:

*tier 1.* the presentation-tier: it manages the experiment

- tier 2.* the middle-tier: it manages the system logic on the server side;
- tier 3.* the storage-tier: it performs the data management, related for example to the management of the user profiles and the distributed management of the data of the available experiments at the different measurement laboratories. It is based on a series of geographically distributed databases, managed using the Relational Data Base Management System (RDBMS).

The LMS is executed on a central server of the distributed laboratory, called Laboratory Portal. The LMS interfaces to the users through a Web Server that is hosted on the same machine. The Laboratory Server (LS) is used to interface a real measurement laboratory with the rest of the distributed architecture. There is a LS for each measurement laboratory of the Universities involved in the project. It delivers the access and the control to the laboratory measurement equipment through a service, called Bridge Service. Moreover, the LS is the only machine in a measurement laboratory directly accessible through the Internet, while the other server machines are not accessible and typically constitute a private local network. For this reason the LS can also be used for security purposes in order to monitor the accesses to the measurement laboratory and to protect it against malicious accesses. The Measurement Server (MS) is a server located in a measurement laboratory that enables the interaction with one or more instruments. A list of some available instruments is reported in Table I. A MS is physically connected to a set of different electronic measurement instruments through an interface card. The GPIB interface has been used to connect the MS to the instruments. The used Virtual Instruments (VI) are stored in a database of the MS, where the LabVIEW environment is installed. No adjustment is necessary to include the VI in the virtual learning environment. Therefore, the wide number of existing VIs can be reused without requiring additive work. In order to overcome the well-known security weakness of Microsoft based networks, each laboratory is protected by a Linux-based gateway machine. One of the most relevant problems designing the laboratory subsystem is the remote visualization and control of the experiments.

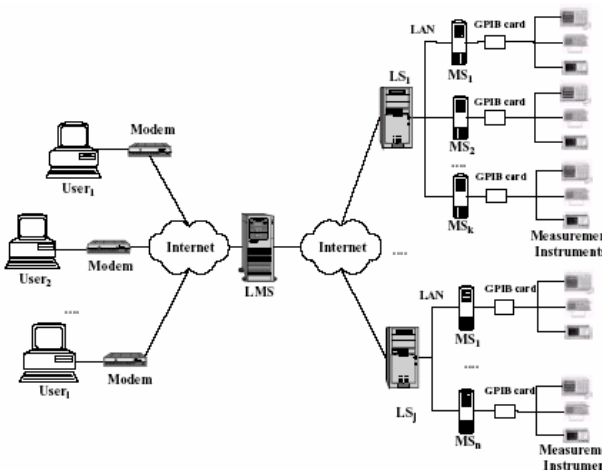


Figure 3 - Hardware components of LA.DI.RE. "G. Savastano".

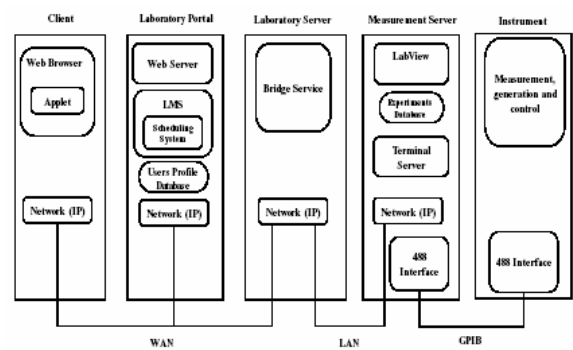


Figure 4 - Software components of LA.DI.RE. "G. Savastano".

### 3.2.2 Delivered services

One of the characteristic features of the *LA.DI.RE. "G. Savastano"* is the inclusion of the functionality of the LMS. The primary objective of the LMS is to manage learners, keeping track of their progress and performance across all types of training activities. The LMS manages and allocates learning resources such as registration, classroom and instructor availability, instructional material fulfilment, and online learning delivery. In particular, concerning the students, the LMS permits to design their own learning process, by carrying out both the collaborative and the project-based learning. Concerning the teachers, the LMS

Table 1. Some available instruments at the *LA.DI.RE. "G. Savastano"* of the University of Sannio

Producer	Model	Type	Quantity
Agilent	E3634A	Programmable DC power supply	3
Tektronix	7704B	Digital oscilloscope	1
Tektronix	TLA5204	Logic analyzer	1
Fluke	5500A/6	Multifunction calibrator	1
Keithley	2002	Digital multimeter	1
Agilent	E6032A	Programmable DC power supply	1
Agilent	53131	Counter	2
Agilent	34401A	Digital multimeter	2
Agilent	34584A	Reference multimeter	1
Agilent	33220A	Arbitrary waveform generator	2
Fluke	PM6306A	RCL meter	1
Keithley	6430	Sub-Femtoamp current meter	1
Keithley	2400-c	Programmable DC power supply and digital multimeter	1
Keithley	6517A	Electrometer	1
Keithley	1801	Nanovolt pre-amplifier	1
National Instruments	ELVIS	Education laboratory kit for experiencing with Virtual Instruments	6
Tektronix	AWG420	Arbitrary waveform generator	1
Tektronix	TDS5032B	Digital oscilloscope	3
Yokogawa	WT210	Low frequency power meter	1
Agilent	E4438C	Vector signal generator	1
Agilent	E4404B	Spectrum analyzer	1
Rohde&Schwarz	SMIQ03B	Vector signal generator	1
Tektronix	TDS5104	Digital oscilloscope	1

makes possible (i) to track the activity of the students, and (ii) to carry out the interactive experiment in the virtual classroom.

The main services delivered by the modules of *LA.DI.RE. "G. Savastano"* to the student are the following:

*Level 0.* Experiment Demonstration: this service allows the students to observe, on-line, how the teacher controls the instrumentation. The student observes on his computer the server desktop used by the teacher to control the measurement instruments involved in the experiment.

*Level 1.* Experiment Visualization: this service allows the student to observe the laboratory activity of the teacher. The student receives on his computer the server desktop used by the teacher to control the measurement instruments of the experiment at "*level 0*". The experiment is carried out by the student operating on the front panel of the LabVIEW VI controlling the involved instrumentation.

*Level 2.* Experiment Control: this service allows the student to perform an experiment by controlling remotely one or more actual measurement instruments. The student can choose a specific experiment in a set of predefined ones and can run it if the required measurement instruments are currently available.

*Level 3.* Experiment Creation: this service allows the student to remotely create an experiment interacting directly with specialized software executed on the servers used to control the measurement instruments. This feature enables the adoption of PBL as didactic model. Under the supervision of the teacher, the students can develop a specific project by producing a VI to control a set of real instruments.

At the end of the theoretical lessons and the experiments the self evaluation tests are given. The services delivered to the teacher are related to the remote handling of the available experiments (remote creation, modification and removal of experiments, etc.). Finally, the administrator of *LA.DI.RE. "G.Savastano"* is responsible of the correct working of the overall distributed system and of handling of user profiles.

### 3.3 *LA.DI.RE. "G. Savastano"* evolution

As above illustrated the activities of the project "Italian-Croatian Remote Laboratory Distributed on Geographic Network" are based on the infrastructure realized for a distance learning laboratory developed at the University of Sannio. During this first phase the web pages of the project (Fig.5) are available by means of the home page of *LA.DI.RE. "G. Savastano"*.

Some experiments are already available in the following fields: digital signal processing, use of oscilloscopes, arbitrary waveform generators, counters, testing of data converters, testing of telecommunication devices. They have been developed mainly in Italian language.

In order to implement new multilingual approach and extend the functions of the laboratory to electric and electronic measurement courses held in the Croatian Universities, partners of the project, one of the first activity of the Italian-Croatian collaboration is the extension to other languages and the set-up of new experiments carried out by Croatian researchers.

This last task will continue the activity, already developed for realizing a prototype experiment for the LADIRE “G.Savastano” in the field of magnetic measurements [3]. This experiment, described in the following, gives to the undergraduate student opportunity of deeper understanding of dynamic hysteresis phenomena and magnetic circuit principles, which are a crucial step for start of work in mentioned areas. The experiment includes an interactive feedback system for verifying the results achieved by the students and, moreover, it is the first experiment available in some European languages [17].

### 3.4 Magnetic measurements

The experiment allows the student to analyze the characteristics of magnetic materials and the influence of hysteretic phenomena on magnetic and electrical circuits. This is the first experiment pointed out (i) to include the interactive verification of the knowledge acquired by the students, and (ii) to be executed in four different languages: Croatian, English, Italian, and Romanian. These new features will broaden the laboratory utility for spreading the communication and the knowledge transfer among teachers and students coming from the Countries where these languages are spoken. This approach follows the current European Union efforts devoted (i) to expand newest educational principles to the partners and neighbor countries, and (ii) to create the

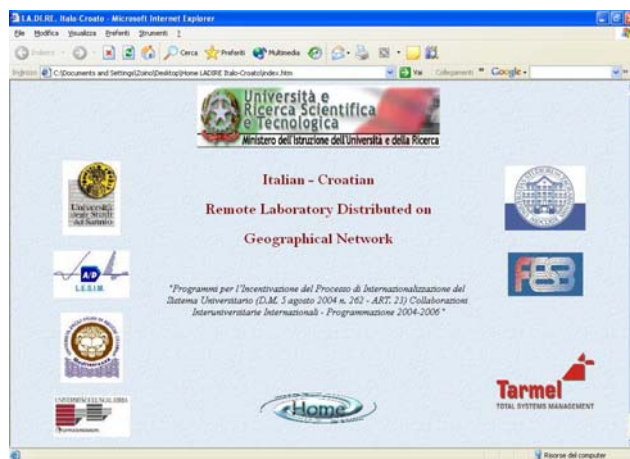


Figure 5 - Home page of the project “Italian-Croatian Remote Laboratory Distributed on Geographic Network”.

European Education and Research Area. By means of the LMS the student is also supplied with documentation including: (i) the theoretical background, (ii) the hardware and circuit descriptions, and (iii) the user guide. Before starting the experiment, the student should have good knowledge of the principles of magnetic circuits. During the practical phase the student will study hysteretic phenomena and how changes in magnetic circuit affect the BH curve.



Figure - 6 Graphical user interface of the developed instrument (GUI).

After performing this experiment the student should be able to examine hysteretic characteristic and estimate its critical values (total and specific core losses, voltage for achieving saturation, coercive force and residual induction of the material and spectral characteristics of main coil current). Experiment is made with two different magnetic materials – a soft and a hard one. This is an important issue for understanding the wide range of currents to be applied to magnetically saturate different magnetic materials. Student has to perform measurements on both of them and compare the results.

The developed experiment is designed as a relevant improvement to the courses and lectures regarding electromagnetism and magnetic measurement topics. Front panel of the experiment is shown on Fig.6. It gives to the student opportunity of deeper understanding magnetic characteristics of different magnetic materials. The developed GUI shows the waveforms of the acquired signals, the current spectrum, the magnetic flux and a BH hysteresis plot (Fig.6). It also computes all of the values which are to be used in further execution of the experiment. At the beginning of the experiment, student is asked to adjust the programmable source to supply the DUT with a voltage that will magnetically saturate the ferromagnetic core. Doing this he/she is able to observe the changes in the given plots and to get practice in determining the point of magnetic saturation. Execution of experiment is continued with source adjusted to mentioned value. During the experiment the student, on the base of the displayed information, has to determine and to read out the critical data from the plots. After that he/she is asked to compute the results and put them in a form provided on the left side of the GUI. The VI verifies that the provided results are in a given range of the actual values (calculated programmatically for the adjusted supply voltage). If the check is passed, the real data is shown on the front panel (until that point this data are hidden). Finally, learner is asked to comment mistakes that he/she has made in the calculations. This feature is giving us the possibility of recording the efficacy of the teaching method by means of a feedback system.

#### 4. CONCLUSION

The paper presented the first results of a Italian-Croatian collaboration for developing a common distance learning system for teaching electric and electronic measurements. The theoretical parts of the courses are provided by a standard LMS, enabling (i) the account management; (ii) the security protection; (iii) the collaborative learning; (iv) the student activity tracking, and (v) the feedback collection. The experiments on actual instrumentation are supported by a distributed laboratory system including remotely accessible instrumentation. The experiments are managed by the students from their homes requiring a web browser only. The remote visualization of the experiments is going to be

improved by means of video cameras and low bandwidth video streaming technologies.

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