IMPLEMENTATION OF REMOTE ACCESS TO WIRELESS COMMUNICATIONS SYSTEMS LABORATORY IN E-LEARNING COURSE

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Abstract

This paper presents our comprehensive approach to e- learning for wireless communications course. Here we describe our experience in design and development phases of remote laboratory environment on radio communications. The proposed approach integrates a traditional Learning Management System (LMS) with the remote access to real instrumentation located in wireless communication laboratory, without requiring specific software components on the client side. The remote laboratory system relying on virtual instruments (VIs) is described in RIPLECS, NI2011 FFOO5 and PAC projects. As being the first attempt in establishing of such a remote laboratory on radio communications, it enables access to high technology RF equipment and setups through the Internet. This paper presents our performance support approach to the design of the wireless communications course in DIPSEIL system (env.dipseil.net/v3). There are listed the tasks and their educational objectives. Here we describe our experience in creating a remote access to the laboratory equipment by External antenna-switching controller board (EASCB).

Keywords: e-learning, remote access, wireless communications, performance support system.

1 INTRODUCTION

Wireless communications related courses include topics that form the backbone of techniques used in industries such as telecommunications, security systems and defence systems. It is highly important for those industries that technical personnel such as engineers and technicians have the practical experience as well as the theoretical background for wireless communications. Laboratory works are important supplement of theory in training of engineers. There are many wireless communications related courses for teaching the theory but not enough laboratory equipment/experiments to support and demonstrate the application of the theory. The main reason is that the equipment required in high-frequency telecom/radio laboratories are of high technology, very expensive, as a result remote laboratory access can enable student to use expensive laboratory equipment, which is not usually available to students. [1].

Nowadays the access to Internet has become a routine for almost everyone in daily life and online education opportunities started to explode. Researchers started to develop new ideas for improving the quality of training by web-based education systems [2,3].

Distance experimentation or web- based laboratory facilities are offered in three forms:

1) Virtual laboratories supported by remote simulation. They are simulated laboratories and hence offer added value to education by providing an experimentation environment without the safety concerns related to actual equipment. Such laboratories could be made accessible through the web for students.
2) Remote “hands-on” laboratories, or briefly, remote labs, provide users Internet-based access to actual (physical) experimental equipment not available on-site.
3) Hybrid laboratories offer a combination of both remote “hands-on” laboratories and virtual laboratories. Among the different types of remote experimentation offered, hybrid laboratories may be considered as the most efficient for both education and research

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1.1 Remote Laboratory in Wireless Communications

In the curriculum of engineering departments many theoretical high-frequency telecommunication- or radio-communication-related courses usually exist to equip students for the needs of industry. These courses are usually supported by various laboratory environments, such as a laboratory on frequency modulation experiment principles, a laboratory on study the antennas and RF-microwaves, an RF hardware design laboratory with project oriented approaches and wireless information networks.

However, there exist several limitations in establishing of those laboratories. Expensive physical experimental setups and their implementation and maintenance should be considered [4]. The lack of laboratory equipment exists particularly for radio communications experimentations in high-frequency ranges, which are used in various consumer devices. That is because, the equipment required in HF radio communications laboratories is very expensive and delicate. Even at the presence of high frequency radio communications laboratories, trainees may not have the opportunity to fully exploit them due to the lack of supervising personnel and restricted time allocation. Then, remote implementation of radio communications experiments would be a good choice, and have many advantages.

1.2 Remote Laboratories Supporting Web-based Performance Support Learning

Web-based performance support learning has been a topic of increasing interest in recent years. The web-based learning platforms usually provide an infrastructure that can be used to create, modify, and manage content for a wide range of learning to satisfy the needs of rapidly changing business requirements. E-learning systems may be implemented in such a way that a customization of features and appearance to a particular learner’s need is supported.

However, huge practical training is absolutely essential to assure good knowledge transfer from teacher to students and to educate good professionals. Laboratory activity is an open challenge for online teaching applied to scientific domains.

In close relation with this issue, it is important to mention the ability of remote laboratories to be integrated with specific web-based project management systems, where they can be seen as additional resources available to the students.

2 EDUCATIONAL OBJECTIVES AND PERFORMANCE-BASED LEARNING

This paper represents our aims at developing a system to enable real-world experiments remotely in an e-learning context of “Information and Communication Systems (ICS)” curriculum. The students will be able to interact with the remote experiment, change parameters and in some cases modify and design experiments.

The course “Wireless Communication Systems” gives students an overview of the characteristics of different types of antennas used in wireless communications and the wave propagation in mobile communication. The course is web-based and is implemented in the performance support system DIPSEIL (Distributed Internet-based Performance Support Environment for Individualized Learning)[5]. The instructional design of the DIPSEIL courses was based on the principles of performance support system (PSS). The approach provides teaching through the development of a task that involves the learners.

DIPSEIL is an integrated electronic environment structured to provide individual online access to the full range of information, guidance, advice, data, tools, and allowing the user to perform the task with minimal external intervention and assistance in convenient time and place.

The structure of DIPSEIL system has: courses, containing modules, containing tasks. Students can obtain modules contents into the learning task. As in modules design, all the tasks are designed in the same format. Each learning task consists of the following elements:

- Task description - the learning tasks is described, explaining the students what is expected of them.
- Reference information - task relevant resources that support students by making immediately available information, which they either have to study or use just in time to perform the task.

- Task-specific training - training materials which help the user to learn while performing the task.
- Instructions how to perform the task.
- Expert advice about a task - expert advice part contains specific advice on performing tasks.

The most relevant step in the learning process, in fact, is the application of acquired theoretical knowledge. Fig.1 shows the task description of the Task 1.1 “Dipole antenna characteristics”. On fig.2 the task-specific training of the same task is represented.

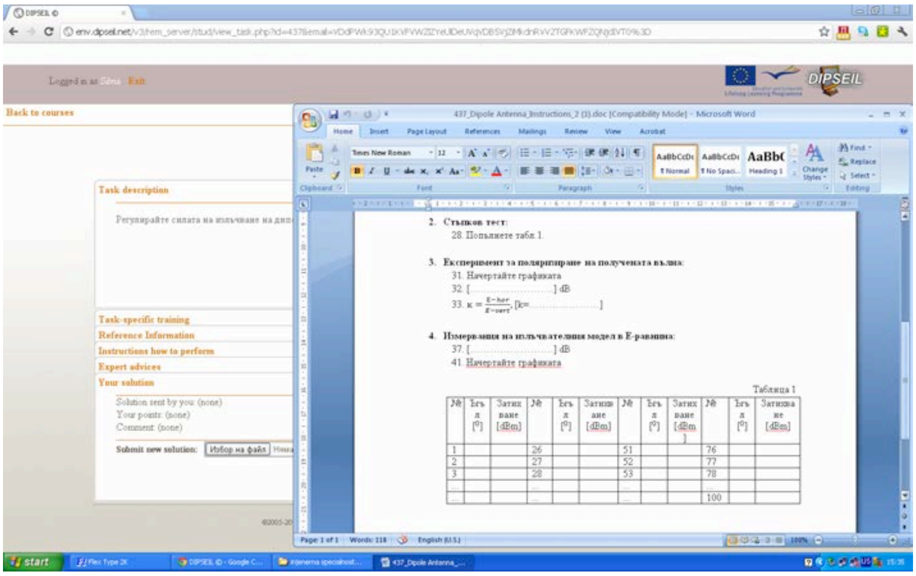

Fig.1. Task description

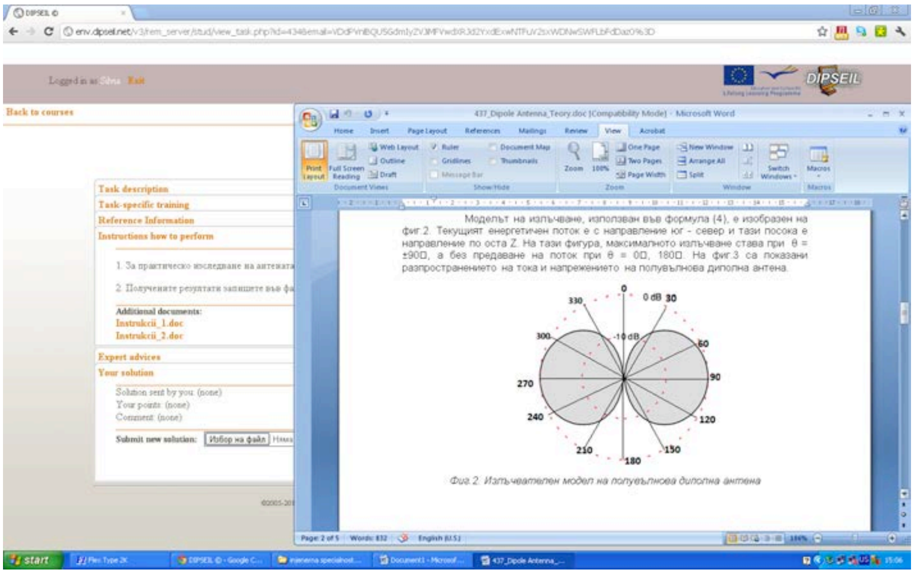

Fig.2. Task-specific training

However, huge practical training is absolutely essential to assure good knowledge transfer from teacher to students and to educate good professionals. The practical part of Wireless Communications course consists of several assignments dealing with understanding the basic functions of the antennas as well as mobile communication propagation characteristics experiments. The laboratory for wireless communications is equipped with specialised expensive instrumentation and test boards, as well as with Wave and Antenna Training Equipment WATS-2000 of Man&Tel Co. [6].

In this paper, a distributed learning platform is proposed to provide full course of wireless communications including theory as well as practical experiments on real instrumentation. The proposed solution integrates the advantages provided by DIPSEIL which is compliant with international standards for Web-based training, and a new approach for providing remote experiments on training equipment.

The remote access to the laboratory equipment is carried out by External antenna-switching controller board (EASCB) which is developed and proposed by our team. The experimental setup is shown on fig.3. Fig.4 represents the EASCB.

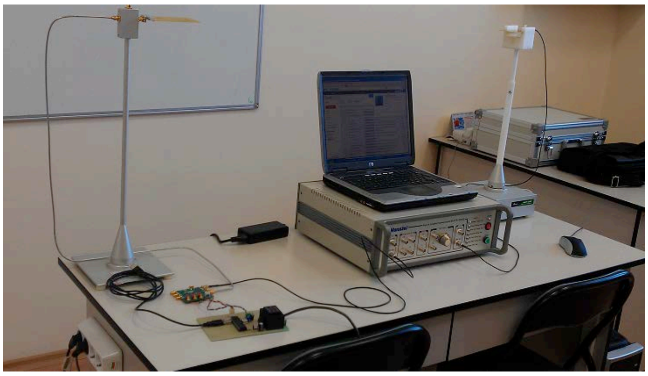

Fig.3. Experimental setup

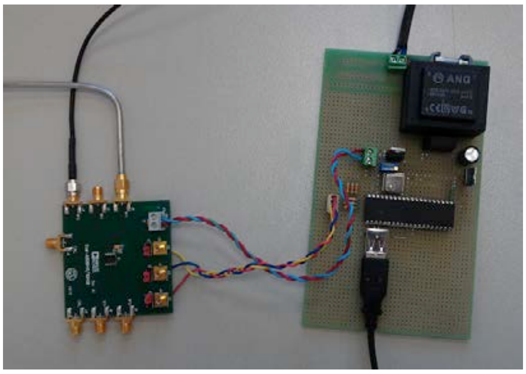

Fig.4. EASCB

Following is the system configuration as shown on fig.5.

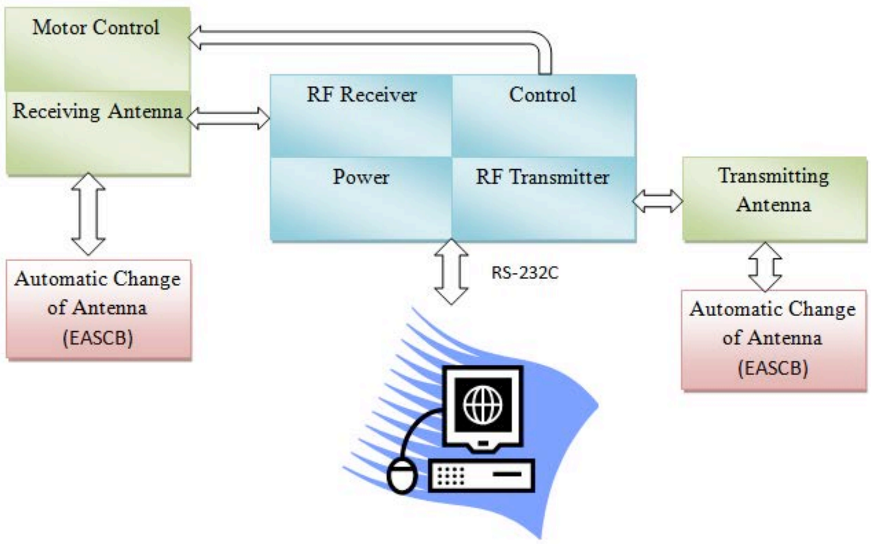

Fig.5. System Configuration

The learning goals of the course are, firstly, to measure the radiation patterns of various types of antennas to get a clear picture on their radiation characteristics. Secondly, wave characteristics experiment in mobile communication are carried out to identify fading, time delay characteristics, voltage standing wave, Doppler‘s frequency and etc. The subject matter is divided into educational objectives. These objectives are learnt in a performance-based manner.

2.1 Antenna Characteristics

In this section the students learn the basic characteristics of Dipole, Yagi, Monopole, Loop, Inverted F, Ceramic chip and Patch and Array antennas. They gain experience in measuring the radiation pattern of E plane and H plane. The educational objectives, which are part of this section, are listed below:

Task 1.1 Dipole antenna characteristics

- Objective 1.1.1 Understanding the basic functions of a half wavelength Dipole antenna
- Objective 1.1.2 Measuring radiation pattern of E plane of a half wavelength Dipole antenna
- Objective 1.1.3 Measuring radiation pattern of H plane of a half wavelength Dipole antenna

Task 1.2 Yagi antenna characteristics

- Objective 1.2.1 Understanding the basic functions of a Yagi antenna
- Objective 1.2.2 Measuring radiation pattern of E plane of a Yagi antenna
- Objective 1.2.3 Measuring radiation pattern of H plane of a Yagi antenna

Task 1.3 Monopole antenna characteristics

- Objective 1.3.1 Understanding the basic functions of a Monopole antenna
- Objective 1.3.2 Measuring radiation pattern of E plane of a Monopole antenna
- Objective 1.3.3 Measuring radiation pattern of H plane of a Monopole antenna

Task 1.4 Ceramic chip antenna characteristics

- Objective 1.4.1 Understanding the basic functions of a ceramic chip antenna
- Objective 1.4.2 Measuring radiation pattern of a ceramic chip antenna

Task 1.5 Loop characteristics

- Objective 1.5.1 Understanding the basic functions of a Loop antenna
- Objective 1.5.2 Measuring radiation pattern of E plane of a Loop antenna
- Objective 1.5.3 Measuring radiation pattern of H plane of a Loop antenna

Task 1.6 Inverted F antenna characteristics

- Objective 1.6.1 Understanding the basic functions of an inverted F antenna
- Objective 1.6.2 Measuring radiation pattern of an inverted F antenna

Task 1.7 Patch antenna characteristics

- Objective 1.5.1 Understanding the basic functions of a patch and array antenna
- Objective 1.5.2 Measuring E plane radiation pattern of a patch and array antenna
- Objective 1.5.3 Measuring H plane radiation pattern of a patch and array antenna

2.2 Mobile Communication Propagation

In this section the students are taught to understand the characteristics of wave propagation in mobile communications and to identify fading, phase delay characteristics, standing wave, Doppler frequency, etc.

The educational objectives, which are part of this section, are listed below:

Task 2.1 Phase delay

- Objective 2.1.1 Understanding the phase delay characteristics of waves
- Objective 2.1.2 Measure phase delay waveform
- Objective 2.1.3 Measure phase delay fading
- Objective 2.1.4 Experiment on fading development caused by combining phase delayed signal and direct wave signal

Task 2.2 Power Attenuation Characteristics

- Objective 2.2.1 Understanding the attenuation characteristics of waves
- Objective 2.2.2 Measure attenuation waveform
- Objective 2.2.3 Measure attenuation fading
- Objective 2.2.4 Experiment on combined waveform of attenuated signal and direct wave signal

Task 2.3 Multi-path Fading

- Objective 2.3.1 Understanding the multi-path fading characteristics of waves
- Objective 2.3.2 Measure fading
- Objective 2.3.4 Experiment on combined fading characteristics when multi path incidence signal possesses separate attenuation and phase delay

Task 2.4 Time Delay and Dopler Effect

- Objective 2.4.1 Understand and experiment the characteristics of time delay wave in mobile communications
- Objective 2.4.2 Experiment on waveform of time delayed data signal
- Objective 2.4.3 Understand the characteristics of Dopler effect
- Objective 2.4.4 Experiment on Dopler frequency according to the speed of mobile and frequency used

Task 2.5 Standing Wave

- Objective 2.5.1 Understand on the standing waves
- Objective 2.5.2 Measure the standing wave pattern
- Objective 2.5.3 Experiment on standing wave characteristics formed by combining incidence wave and reflection wave

3 CONCLUSION

The development of the remote laboratory environment on radio communications pretends to meet the distance learning needs avoiding the students to travel to perform face-to-face practices. With this system both University and students obtain benefits. University saves money and increasing reputation and prestige by the continuously innovation. Students continue their normal life without leaving the work or the family home.

For the education and training of our students:

1. We are going to realize practical tasks performance in courses, for which work in a real laboratory is absolutely necessary, through remote access to labs. The remoteness serves as an additional new instrument to the innovative performance-centered system with educational elements.
2. As a new technology, performance-centered system will move the education process to the learning embedded in the contexts of the “supposed workplace”.

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