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A Classroom/Distance Learning Engineering Course on Wireless Networking with Virtual Lab

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Abstract

This paper presents the design of an engineering course on "Wireless Networking" in a traditional classroom /distance learning format. The paper will also show that how classroom learning can be enhanced by making available to learners the classroom lecture in audio /video/pdf format from anywhere and at all times on demand. This technology enables the distant, absent and those students who have lost concentration in the classroom, the experience of the classroom environment beyond the physical classroom. In this method, the students can concentrate on learning and not be distracted by having to take notes in the classroom. For instructors, the technology is as easy as writing on transparencies. The legacy classroom lecturing is preserved in this technology except the lack of visual feedback. The method requires minimal training in the transition for both the teacher and the learner. Technology is the result of integration of Microsoft Power Point (tablet version) and a third-party software for capturing and embedding the audio and video parts of the lecture.

The course includes three components: a) content, b) virtual laboratories and c) project. The course content consists of enabling technology, deployment in networking infrastructure and the management of wireless networks. The virtual lab is based on the pioneering simulation-based online virtual laboratories in wireless communications and networking, developed and commercialized by ATeL, LLC. The labs are designed for a new, so called digital generation of learners and cater to varied and newer learning styles. The students are required to prepare the design of a wireless network for a local area in the vicinity of the campus, taking into account local terrain and the networking needs specific to the area. Project design is the capstone activity involving literature search and application of multiple learned concepts and techniques. This course is being taught as a senior/graduate level class.

I. Introduction

Accessibility and mobility advantage has rendered wireless networking to be the preferred technology for providing broadband networking services in the modern communication and networking industry. The wireless networking is now being deployed in the Metro environment with new and innovative network topologies and network management strategies. The traditional course on Wireless Communication is not enough to fulfill the needs of this modern industry. There is a great need of technology professionals who not only understand and design the wireless components and subsystems, but can also design networking systems and their architectures, fault management and network protection systems. The proposed course aims to prepare technologists to meet this demand.

The learning needs of modern distance learners are changing [1], and the teaching methodology must come up to meet the new challenges. Technology can help greatly in this endeavor [2]. Today, the preparation of engineering technology graduates, who deeply understand the fundamental principles behind contemporary state-of-the-art technologies, but also exhibit analytical, problem solving, and expert thinking skills, is impossible without incorporating new educational tools and teaching methodologies into curricula so that students can acquire digital-age literacy for becoming life-long learners. However, incorporation and implementation of state-of-the-art technological tools requires considerable investment of time and financial resources. Keeping curricula and lab resources current with respect to the fast pace of technological advances in the field is another challenge for faculty.

College and university professors can address some of these challenges by using simulation and virtual experiments. With the wide availability of broadband technologies, which offer high data rate connections, simulation-based e-learning is rapidly becoming a significant and effective element of the teaching and learning process. The use of virtual systems enables distance learning students to master practical skills at any time and any place.

II. Lecture-On-Demand Technology

There is a need for a method of connecting the teacher and the learner that will enhance the learning experience and have a new paradigm in classroom instructional delivery and/or outreaching to distant and non-traditional learners. Several experiments and methods are being tried and the related issues are being discussed [3-7, and 9-11]. Tegrity Inc. [8] has a solution that is very good, but it is expensive and does not let the teacher take full command of the process. The technology of Lecture on Demand[12] is a low-cost solution and provides the instructor full command of the teaching-learning process. This technology is also very effective in other parts of the world where students in some institutions have to learn the courses themselves in the absence of instructors. It can also enhance the on-line tutorial experience which is essentially an asynchronous activity.

In the method of lecture on demand, the production and delivery are all done by the instructor himself without any complicated gear and without any assistance. Teacher has the flexibility of recording the lecture in a studio or in the real classroom with students in the synchronous manner or in studio or at home or elsewhere. The instructor uploads the lecture in totality (video+audio+pdf) on a website and the learners have access to it at all times and from anywhere. The students have access to the teaching material off the classroom for repeated viewing, and for learning on their pace. It is a great help to those who missed out in the classroom, came late or did not show at all. The objectives of the course based on this technology are:

1) To record both audio and video in the classroom lecture.
2) The lecture recording must be as easy as possible with minimal gear and minimal training.
3) To publish lecture on the Web along with other instructional materials

Figure 1 shows a web page in the demonstration of Lecture on Demand technology of instruction delivery. The http://ecet0.calumet.purdue.edu/JPA/lectureondemand.htm. web page shows how to record the lecture in audio-video using .wmv file and create a soft copy of the lecture as a .pdf file:

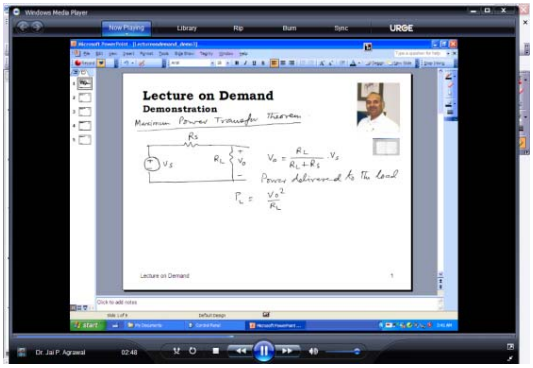

Figure 1 Demonstration of Lecture on Demand method

This method is very similar to and as easy as the conventional lecturing by writing on transparencies in the classroom. PowerPoint (2003 or higher) blank on a Tablet PC substitutes for the transparency. The Heulix[3] software records every movement of the inking pen on the screen along with the lecturer's voice synchronously. No video camera is needed, although, a Logitec camera may be added to show the instructor speaking. The Powerpoint file may either be written live in the classroom or pre-written before the class. Text, hand drawn figures and scanned figures in the Powerpoint file, all can be animated to suit the effective delivery of the lecture content. Additional ink annotations can always be added live in the class. Figures can also be drawn live in the class room or added as scanned figures from the textbooks or somewhere else. The demonstration is available as demo I and II on the above website.

The Huelix software allows selection of the quality of the video/audio recording on a wide range from finest to the lowest resolution. The file size for optimum recoding quality is approximately 500 Kbits per minute of recording. A lecture of 75 minutes is recorded typically in a 35 Mbits file. Learners will require a high-speed broadband connection for complete download, else it may be streamed. Learners with limited Internet speed can be provided lectures on pre-recorded CDs or DVDs.

III. Course Description

The course, "Wireless Networking" is a dual-level course targeted towards the senior year undergraduates and the first year graduate students. It introduces the fundamentals and the topics that are essential for those who aspire to enter in the modern communication networking industry. The website for the general information is given at http://ecet.calumet.purdue.edu/tech581a_wn. This course is offered as the distance learning basis. Students require username and password for access to lectures, simulations and the gradebook.

A. *Goals and Objectives*

The purpose of this course is to provide the student with knowledge and experience on the enabling technology, wireless networking architectures, protection and fault recovery and management of wireless networking systems. At the end of the course the students will be able to design and manage an wireless network project.

Figure 2 Course website

B. *Course Syllabus*

An introduction to components, systems and the enabling technology and the underlying the wireless networking technology. Topics include basics of cellular telephony, paging, antenna diversity, spread spectrum, carrier hopping, mobile and multi-user access, Wi-Fi, and Wi-Max, CDMA, GSM, Bluetooth technology and ad-hoc networking. Wireless access architectures and design will be the primary focus of the course which includes architectures, fault and alarm handling, protection schemes and network management.

C. *Major Learning Objectives*

After successfully completing this course, the student will learn:

1. The enabling technology in the wireless networking.
2. Components and subsystems used in wireless networking.
3. To design wireless networking systems.
4. Protocols and principles of operation, administration and maintenance of wireless networks.
5. To interface the wireless networks to LAN, MAN and WAN.

D. *Textbook*

Principles of Wireless Networks – Kaveh Pahlavan & Prashant Krishnamurthy, P-H 2002

E. *Reference Books*

1. Wireless Communications: Principles and Practice, Rappaport, T. S. (2nd ed), P-H, 2002.
2. Wireless Networking – Charles N. Thurwachter Jr., Prentice-Hall, 2002

F. *Modules*

Week	Topics	Reading
1	Background: Data transmission fundamentals, Randomness, probability and correlation	Notes
2, 3 and 4	Wireless propagation and mobility fundamentals	Ch. 4, 5
5	Cellular Communication systems	Ch. 3
6	Modulation techniques	Ch. 6
7, 8	Coding and diversity	Ch. 7, 8
9	Multiple access: FDMA, TDMA, CDMA, SDMA, Packet Radio	Ch. 9
10	GSM, OFDM	Notes
11	Spread Spectrum Techniques	Notes
12	RFID Technology	
13	Wireless Networking: WiMax, UWBM	Notes
14	Blue tooth technology	
15	Make-up and Review	

G. *Submit Classwork and Grading*

The students submit their work on-line. Each student accesses his/ her page and uploads the files. The students is not permitted to change the uploaded file, but are allowed to add corrections or modifications. No student can see other's work. The students' grades are continuously updated. They can see their grades and also their updated relative ranking in the class dynamically.

IV. Simulation And Virtual labs

Simulation-based interactive virtual labs, developed by the Massachusetts-based company ATeL LLC with support from the U.S. National Science Foundation are a significant part of the course. This educational tool has been designed to meet expectations and learning habits of a new generation of learners who grow-up with computers and gadgets. Realistic images, animations and highly interactive simulations are key elements of the described e-learning solution. In the proposed approach, the use of the interactive virtual labs promotes and facilitates active learning and conceptual understanding, rather than passive exposure and simple memorizing of dry information.

Laboratory exercises enable students to learn fundamental principles in the context of their practical applications in actual fiber optics and photonics devices and telecommunication systems [19, 20]. This helps students to learn the relationship between scientific theory and its practical applications in technology, visualize the processes occurring in the system, and better understand system limitations and bottlenecks.

The core components of all virtual labs discussed in this paper are highly interactive complex Java and Adobe Flash simulations with associated HTML/XML parts and scripts. State-of-the-art graphical interfaces and realistic models of the simulations provide an "insight" view of the process and help users become familiar with the internal structure and operation of complex telecommunication systems and devices. Many of the virtual labs and experiments may be linked to hands-on labs to provide a hybrid lab environment.

The virtual laboratories implement technologies that provide instructional opportunities in many ways, whether in a traditional classroom or through distance learning anytime and anywhere. Using highly interactive and realistic simulations students can:

(1) Observe and gain insight into physical processes at different levels of detail
(2) Analyze constraints between relevant parameters
(3) Push these parameters beyond normal allowed values to simulate infrequent operating conditions or casualty situations
(4) Run "what if" scenarios
(5) Acquire data from virtual experiments for detailed analysis and comparison to actual operating conditions in a theory-to-practice approach.

Each virtual lab contains an expandable set of virtual experiments, learning resources, and assessment activities. An easy-to-use tool that enables instructors with no programming experience to produce appealing and pedagogically sound interactive virtual activities is available as well. Fig. 1 shows an example of ATeL virtual lab. For more information about virtual labs please visit ATeL website http://ATeLearning.com**.**

The following ATeL virtual laboratory exercises are used in the course:

Exploring Cell Sectoring
Investigation of Cell Splitting Procedure
Exploring Trunking Procedure
Multiple Access
Exploration of a Cellular Phone and Signal Transformation Stages in it
Evaluation of the maximum number of users in a system
Redistribution of channels in different sized cells
Cell size dependence on user's movement speed
Intersystem communications
Calculation of the probability of blocking for a system

The fact that students do not have a direct hand on the labs, is a debatable limitation of virtual labs. Author's views are that to impart the same amount of education using hardware implementation of labs is more difficult, time consuming and expensive. To find out about the software tools to create own virtual labs, it is advised to contact the second author on ycherner@atelearning.com.

V. Design Project

The design project is the corner stone of this class. This is where the students apply all the learned principles and acquire the knowledge of components and subsystems available from the various vendors in the industry. The student is required to prepare the design of a broadband wireless MAN in the neighborhood area, select components, devise the plan for the network management, fault management and protection systems while meeting the networking needs. A written report and power-point presentation are required at the end of this course. Following is the definition of a design project:

Prepare a Project report and the PowerPoint presentation on *WiMax Technology* comprising of 15 or more slides. You can search on Internet and other sources but narration must be yours. The topics you should include (but not limited to) are:

- Need for the technology, comparing with alternatives and list their shortcomings that it overcomes, IEEE802.16.
- Salient features
- Enabling technology

- WiMax PHY layer
- WiMax MAC layer
- WiMax network architecture
- Link-level performance
- System-level performance

Figure 3. Screenshots of the virtual lab

Virtual lab as shown in Figure 3 above enable students to explore the number of mobile phone users that can be served by a wireless local area network (WLAN) and the Cell Splitting procedure. While studying the procedure, students can vary blocking conditions, number of subscribers in large cells, determine the threshold, split the sells and assign the channels to the microcells, and investigate handoff process in a WLAN of different configurations. The simulation runs with a detailed step-by-step instruction for the student on how to perform the experiment. Students are able to collect virtual data and record them on the provided worksheet. An interactive lesson incorporated in the lab (bottom left) facilitates "just-in-time" learning of underlying scientific or engineering principles. Each virtual experiment includes an associated test.

VI. Summary

The course on Wireless Networking is new dual-level engineering/technology course that introduces the enabling technology, modern network architectures and networking principles and practices. This course has been offered both in the classroom instruction as well as on the distance learning basis via web-instruction. Students are at first overwhelmed by the amount of new information, but love to work through the virtual laboratory exercises.

Come design project and they have lot of questions, but learn a great deal and enjoy while surfing for components and existing technology and practices. The distance-learning students were at first apprehensive of on-line lectures, but later they expressed satisfaction that they did not miss the classroom at all.

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Biographies

Jai P. Agrawal is Professor of Electrical and Computer Engineering Technology. He received his Ph.D. in Electrical Engineering from University of Illinois, Chicago, in 1991, M.S. and B.S. also in Electrical Engineering from I.I.T. Kanpur, India in 1970 and 1968 respectively. Professor Agrawal has worked recently for two years in optical networking industry in the Silicon Valley in California. Professor Agrawal is the Founder Advisor to Agni Networks Inc., San Jose, California. His expertise includes optical networking at Physical and Data link layers, optical and WDM interface, SONET and Gigabit Ethernet and analog electronic systems. He is the author of a Textbook in Power Electronics, published by Prentice-Hall. His professional career is equally divided in academia and industry. He has authored several research papers in IEEE journals and conferences.

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