

A Web-Based Tool for Teaching WLAN Design Fundamentals to Undergraduates

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INTRODUCTION

Wireless communication and networking courses are becoming increasingly popular in universities, polytechnical institutions, postsecondary colleges, and private training institutions around the globe. This popularity is partly because of rapid developments in wireless communication and networking technologies and the high demand for wireless networking skills in the industry worldwide. Unfortunately, motivating students to learn *wireless local area network (WLAN)* design is often difficult because students find the subject rather technical, and dry when presented. To overcome this problem, we have developed a Web-based software tool (named WLAN-Designer) that gives students an interactive learning experience in WLAN design concepts. The *WLAN-Designer* is suitable for classroom use in introductory wireless networking courses (undergraduate IT and CIS curricula). The effectiveness of WLAN-Designer has been evaluated by both students and teaching teams. The implementation of WLAN-Designer was judged to be successful because of the positive student feedback and also students scored better in the final examination. This chapter describes WLAN-Designer and its effectiveness as an aid to teaching and learning WLAN design concepts. The impact of WLAN-Designer on student learning and comprehension is also discussed.

BACKGROUND

Wireless networking is often included as a subject in computer science, information technology (IT), engineering, and business courses because wireless networks are a fundamental component of IT systems today. Research has shown that students learn WLAN design fundamentals better, and feel more engaged with their courses if they are given interactive exercises that

illustrate theoretical concepts (Midkiff, 2005; Richards & Waisbrot, 2002; Sarkar & Craig, 2006). Therefore, we have developed a Web-based tool called WLAN-Designer that facilitates an *interactive teaching and learning* of various aspects of WLAN design.

Many educators have experimented with various approaches to alleviate the problem of motivating students to learn technical subjects. For example, computer assisted learning packages (Diab & Tabbara, 1995), game-based simulation (Shifroni & Ginat, 1997), approaches based on the *constructivist paradigm* (Chen, 2003), *experiential learning* (Chang, 2004), and learning research techniques such as the phenomenographical approach (Berglund, 2003). This chapter introduces a *Web-based flexible learning tool* (WLAN-Designer) for teaching WLAN design fundamentals. WLAN-Designer provides online support for off-campus students by engaging them in a flexible and learner-centered manner. This interactive and flexible learning approach to WLAN design is used for three years now in the e-Business IT Infrastructure (EBITI) undergraduate courses (IT curriculum) at AUT University, Auckland, New Zealand. This course covers various aspects of *wireless communication and networking* fundamentals.

Wireless networking fundamentals are described in many textbooks (Carter & Whitehead, 2004; Holloway, 2003), and Web-based tools are discussed extensively in the literature (Aller, Kline, Tsang, Aravamuthan, Rasmusson, & Phillips, 2005; Djordjevic, Nikolic, & Milenkovic, 2005; Garcia & Alesanco, 2004).

The main contribution and strength of this chapter is the emphasis that interactive learning experience using a Web-based tool is crucial in motivating students to learn WLAN design concepts. The most innovative aspect of this work is the development and evaluation of such a tool to be effective in complementing the lecture content of the course. A review of existing network simulation and modeling tools is presented next.

EXISTING TOOLS: A REVIEW

Many useful computer programs and software are available for teaching and learning of wireless communication networks. They range from simple simulators, to specific teaching and learning tools, to advanced and specialized software. The author tested several of these packages for the purpose of teaching introductory wireless networking courses. The motivation for designing such tools is to provide an alternative environment for a live network so that students can experiment with various network topologies without any risks of damaging the networks (Davis, Ransbottom, & Hamilton, 1998; Tymann, 1991). However, both open source and commercial *software packages* can have steep learning curves, and they often simulate a network environment in far more detail than is necessary for a simple introduction to the subject (Chang, 1999; Zheng & Ni, 2003). What makes WLAN-Designer (also WebLan-Designer discussed later) distinct is that it is simple, easy to use, and provides a set of learning resources, such as interactive quizzes, modeling, scenarios, key terms and review questions into one tutorial suite, and that students can learn at their own pace. Some of the software tools reported in the computer networking literature are briefly described below.

Netwire emulator (Carniani & Davoli, 2001) is a software tool suitable for teaching advanced computer network protocols (e.g., data link layer protocols). EMPOWER (Zheng & Ni, 2003) is a network animator that can be used as an aid to illustrate the concept of both wired and wireless networks. However, EMPOWER requires students to have some basic knowledge about computer networks.

Cnet (www.csse.uwa.edu.au/cnet/) is a network simulator that enables experimentation with various protocols at the data link, routing, and transport layers. However, cnet requires students to have some basic knowledge of Linux/Unix system. Dlpjava (King, 2006) is a network simulator that can be used in enhancement of teaching data-link protocols through simulation.

Various network simulation packages are available for modeling and performance evaluation of computer networks. For example, ns-2 (www.isi.edu/nsnam/ns) is one of the most popular network simulators among the researchers, especially computer science (CS) and electrical engineering (EE) students worldwide. Ns-2 is available free of cost, and provides an environment for rapid model development. However, ns-2 has a

text-based interface that is not user-friendly. Various commercial tools, such as NETWORK II.5, and COMNET II.5, suitable for teaching and learning network modeling and simulation (Garrison, 1991). OPNET (www.opnet.com) is another commercial package commonly used by researchers and practitioners for modeling and simulation of complex communication networks. OPNET is suitable for teaching advanced networking courses, but is a very expensive package for educational use.

In summary, WLAN-Designer is different in its goals and capabilities. The architecture of WLAN-Designer is described next.

MAIN FOCUS: WLAN-DESIGNER, AN INTERACTIVE LEARNING TOOL

The system described here is easy to use and reliable, and can be used to enhance the teaching and learning of various aspects of WLAN design concepts. Figure 1 shows the structure diagram of WLAN-Designer.

WLAN-Designer provides the following main features:

- *Home*: The home page contains the project title, author's name, and links to various pages of the WLAN-Designer including design, standards, technology, protocols, topology, and feedback. The user can easily navigate the Web pages using the point-and-click graphical user-interface (Figure 2).
- *WLAN information*: The system provides both the general and technical information of wireless network design through the various Web pages.
 - *Overview*: This page provides an introduction to WLAN design.
 - *Network standard*: This page highlights the most common WLAN standards such as IEEE 802.11b/a/g.
 - *Technology*: Wireless networking technologies, including frequency-hopping spread spectrum (FHSS), direct sequence spread spectrum (DSSS), and orthogonal frequency division multiplexing (OFDM), are discussed.
 - *Protocol*: This is an important matter that needs to be considered when designing WLANs. The channel-access protocol ef-

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