Hands-On Laboratory Experiments in Data Communications and Networking

A Proposal for the UCTL Teaching Enhancement Grants Program

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1 Project Description

This proposal requests funding to provide the hardware necessary to more fully prepare CSU students to be able to set up or maintain networks using current and emerging networking technologies. Networking is one of the fastest-growing and important fields in the computer industry today. The Internet, interconnecting millions of computers, provides a global communication and resource-sharing infrastructure which elicits many changes in the workplace and in working style. These changes create a growing need for small business and home networks. No computerized office today is able to be productive without some sort of networking technology. Working from home over a network during both business and non-business hours is now currently standard. Realizing these various types of networks requires professionals who are familiar with a variety of networking technologies. CSU students cannot be expected to compete in the current job market unless they can demonstrate to prospective employers that they have networking experience that goes beyond the purely theoretical. This proposal intends to outline the various current and emerging networking technologies and the strategies that will be used to train students in these technologies in coordination with the CIS 454/554 Data Communications and Networking course.
2 Project Goals

The short-term goal of the proposal is, as discussed in the description, to more fully prepare CSU students to be able to set up or maintain networks using current and emerging networking technologies. A laboratory instruction manual and an instructor’s guide will be developed for training students in these technologies.

The longer-term goal of this project would be to improve the quality of CSU’s CIS curriculum in general. If CSU is correctly perceived to be a place where students can gain practical experience in networking, we can reasonably expect that this course enhancement might be positively reflected in enrollment statistics, employability of CSU students, and overall employer satisfaction with CSU students.

3 Proposed Activities

Five networking technologies are in widespread use now or are likely to be in widespread use in the near future. These networking technologies correspond to five proposed lab activities that will attempt to train students in the following essential networking skills:

1. Router/Firewall Configuration
2. Wireless LAN Configuration
3. HPNA (HomePNA) Installation
4. Powerline Configuration
5. Network Security

The following proposed lab outlines discuss the equipment needed for each lab activity and the actual lab activities themselves. These lab descriptions would need to be developed further before being given to students carrying out the labs. However, the lab outlines below are provided so that it can be seen what equipment is necessary and the general learning goals of each lab activity.

3.1 Router/Firewall Configuration

Objective: To teach students the Network Address Translation (NAT) protocol and to setup a firewall on a router.

Description: Students will connect the router as shown in Figure 1. The WAN port on the router is connected to the laboratory Ethernet LAN to emulate the connection to a cable or DSL modem at home or in a small office. Students will study how the NAT protocol
works for an invisible home/office LAN. They will use the PC1 and the Linux work-
station (in Figure 1) to login the server grail. When checking the login source, students
will find out both logins are from the router. That is, NAT allows multiple computers on
a network to share a single IP address. Students will also gain hands-on experience in
setting up a firewall to block in-bound and/or out-bound traffic, enabling a virtual Web
server, and related topics.

**Hardware needed:** one router, two additional Ethernet cables, two PCs with Windows XP
installed, and one Linux workstation.

**Duration:** Two hours.

### 3.2 Wireless LAN Installation

**Objective:** To teach students how to configure a wireless LAN in infrastructure mode and ad
hoc mode.

**Description:** The IEEE 802.11b standard for wireless LANs defines two operation modes:
infrasture mode and ad hoc mode (see Figure 2). The former consists of at least
one Access Point (AP) connected to the Distribution System (i.e. wired network) and
a number of wireless end stations. This topology is called a Basic Service Set (BSS).
All stations communicate with the AP and do not communicate directly with each other.
Frames are relayed between stations by the access point. The latter mode (i.e., ad hoc
mode) simply consists of a set of wireless stations that communicate directly with one
another without using an AP. The point of this lab is to configure a wireless connection
working in both infrastructure mode and ad hoc mode with 2 computers, and in ad
hoc mode with 4 computers. Students will also practice changing the communication
channel to avoid collision with other wireless LANs and to set up an encryption key for
Wired Equivalent Privacy (WEP).

**Hardware needed:** One wireless router (wireless access point), two wireless adapters, one
additional Ethernet cable, and two PCs with Windows XP installed.

**Duration:** Two hours.
3.3 Phoneline Networking

Objective: To use existing phone lines to connect computers.

Description: HPNA (Home Phoneline Networking Alliance) makes use of existing telephone cable as the physical medium for networking. It uses a higher frequency bandwidth than voice operations or DSL and hence does not interfere with voice operations or DSL on the existing telephone line. That is, three different signals, voice, DSL, and HPNA, can occur on the same phone line simultaneously. For computers located in different rooms, HPNA uses the existing wiring infrastructure and is easy to install. In this project, students will learn how to set up local networks through existing phonelines.

Hardware needed: Two HPNA USB Adapters with USB Cable and two PCs with Windows XP installed.

Duration: One hour.

3.4 Powerline Connection

Objective: To teach students how to use the HomePlug standard to establish a network using existing AC powerlines.

Description: The point of this lab is to configure a connection whose signal goes over a power line. The way a powerline connection basically works is that the network signals operate at a higher frequency than the power frequency, so the same wire can be used for both power and a network connection without interference. The students will establish a powerline network connection in two configurations: a) a computer connected to a LAN via the powerline bridge, and b) 2 computers connected to each other with no connection to the outside world (i.e., node to node). Figure 3 shows the configuration that a powerline-based network would need in order to share an Internet connection, an example of configuration a), above.
**3.5 Network Security and Sniffing**

**Objective:** To observe the vulnerability of communications on a network using a shared bus and to observe how adding switches to the network configuration results in better security. Also, to learn how data encryption can play a role in network security.

**Description:** Students will learn about network security from this activity. They will use a network sniffer to capture various packets transferred through an Ethernet hub. Students will learn how a switch can be used to provide more secure separated LAN segments and how SSL can be used to encrypt and protect data.

**Hardware needed:** One Ethernet Hub, one Ethernet switch, and two Sun workstations.

**Duration:** One hour.

### 4 Assessment Method

To evaluate the effectiveness of the proposed lab activities, our assessment method will be threefold. Firstly, we will use student evaluations from the above course to reflect the quality of the networking course and hands-on lab. We plan to survey students on how much they learned, how satisfied they were with the lab activities, and how they would improve the hands-on lab for future classes. So that our assessment isn’t dependent on purely subjective measures such as student evaluations, we also plan to give a short written test before and after
the hands-on lab to evaluate which activities were the most helpful in students’ learning and which activities might require adjustment. Finally, we plan to give a live test where each group must perform the various types of network setups. More than any other measure, a test of this last sort will most accurately reflect whether students would be able to achieve the intended goal of this project: to competently set up their own networks in the home or in the workplace.

Also, as we continue to gather enrollment statistics, we will be able to measure the impact of this course enhancement on overall enrollment. Additionally, we propose to conduct a survey of employers to measure job performance of CIS graduates, including those who took CIS 454/554. If CSU is correctly perceived to be a place where students can gain practical experience in networking, we can reasonably expect that this course enhancement might be positively reflected in both enrollment statistics and overall employer satisfaction with CSU students.

5 Budget and Justification

To support the proposed activities, we request funds for purchasing the following networking equipment:

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<th>Item</th>
<th>List Price</th>
<th>Qty</th>
<th>Sub-total</th>
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<td>$480</td>
</tr>
<tr>
<td>Wireless Access Point</td>
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<td>Wireless Adapter</td>
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<tr>
<td>Phoneline HPNA adapter</td>
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<tr>
<td>Powerline adapter</td>
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<td>$420</td>
</tr>
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<td>Powerline bridge</td>
<td>$70</td>
<td>6</td>
<td>$420</td>
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<tr>
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<td>6</td>
<td>$240</td>
</tr>
<tr>
<td>5-port Switch</td>
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<tr>
<td>Estimated Total Cost</td>
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<td></td>
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</table>

There are roughly thirty students taking CIS454/554 each semester. We will select six volunteer students to be laboratory assistants and to receive training before any of the other students. We plan to divide the remaining students into twelve groups where each group has two students. To reduce the requested cost, we intend to have six groups do the same project and the other six groups do a different one, and then have these two sets of groups swap projects during the next lab period.

6 Expected Outcome

The expected outcome of this course enhancement would be the original goal of the proposal: to more fully prepare CSU students to be able to set up or maintain networks using current
and emerging networking technologies. We have outlined the hardware required for this, the lab activities we intend to follow, and the methods we will use for accurate assessment of the success and continuous improvement of the proposed lab activities. After going through the CIS 454/554 course, students can be expected to be better prepared to find jobs in the field of networking and in computer-related industries. It is also expected that the course will have an overall positive effect on the quality of CSU’s CIS curriculum and enrollment.

We also intend to share our experiences with educators in other universities. Laboratory manuals and student projects that result from these lab activities will be submitted to the IEEE Transactions on Education and/or the Computer Education publications.

7 Timeline:

We have a tentative seven-month schedule as follows:

**November - February:** Purchase the special hardware after the proposal is funded. The graduate assistant and I will conduct the proposed lab experiments and write the step-by-step procedures into a lab instruction manual. We will also write an instructor manual to aid the volunteer laboratory assistants in the preparation tasks before the lab and the clean-up tasks after the lab.

**March - April** A short pre-test of networking knowledge will be performed in order to establish a baseline before the hands-on lab. We will then schedule five 2-hour or 1-hour labs in March and April. All groups should be able to complete the experiments during the lab hours. Live practical tests will be performed during the last lab session. Survey forms will be distributed to students after this entire process.

**May** We will consider student feedback while revising the lab instruction manual and post the lab instruction manual in a class web page for future CIS 454/554 classes. We will also at this time complete and submit a final report for publication in educational journals.
Appendix: Endorsement

I support and endorse this Course Enhancement Plan.

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Signature                  Date
Chairman, Department of Computer and Information Science