

Laboratories for Data Communications and Computer Networking

Raj Jain, Steve Lai

Rohit Goyal, Shivkumar Kalyanaraman, Ting Lin

Department of Computer and Information Science

2015 Neil Ave., 395 Drees Lab

The Ohio State University

Columbus, OH 43210

{jain,lai}@cis.ohio-state.edu

1 Overview of Goals and Objectives

The primary goal for the project is to design a series of laboratories for data communication, computer networking and telecommunication, which will allow the student to experiment with various communication protocols. The specific goals for the project are listed below.

- Provide a hands-on lab oriented curriculum for computer networking.
- Enable students to develop new protocols and modules and to experiment with their design.
- Use a distributed gaming/simulation environment to allow experimenting with unpredictable behaviors.
- Use multimedia techniques to show the effects of various actions and events.
- Provide for easy transfer of the product to other educational institutions.

2 Current Status and Accomplishments

We have accomplished the first three goals in the original proposal. The simulation environment is described in section 4. So far, we have developed three labs:

- Lab 1: Interlayer Communication
- Lab 2: Sliding Window Protocol
- Lab 3: Go-back-N ARQ

In these labs, students develop a simple data link layer that performs flow control using the sliding window protocol, and loss recovery using Go-back-N. Students are given the skeleton of a basic data link layer, and primitives for inter-layer communication. They develop the data link layer using the C programming language. They use built-in physical layer and application layer modules to experiment with their data link layer using different configurations and link error rates. They use the graphical user interface (GUI) provided by the simulator to understand the functioning of the protocols.

3 Plans for Remainder of Project

The following table shows the schedule for the completion of the remaining labs.

Lab #	Title	Completion Schedule
4	CSMA/CD Medium Access Control Protocol	Dec 96
5	TCP	Dec 96
6	Routing in a Wide-Area Network	Mar 97
7	ATM Traffic Management	Mar 97
8	Token-Based Medium Access Control Protocol	Jun 97
9	DQDB Medium Access Control Protocol	Jun 97
10	Interconnecting LANs with Bridges	Sep 97
11	X.25	Sep 97
12	B-ISDN Signaling	Dec 97

Completion of a lab includes the following components:

- Developing the network protocol code.
- Developing the lab assignment (i.e., what the students will do in the lab).
- Developing the multimedia user interface and fine-tuning it for each lab.
- Documenting the protocol and the lab assignment.
- Porting to the PC (Linux) environment.

4 Materials That Have Been Developed

We have developed a simulator environment that will support all the labs in this project. The first 3 labs have been developed on this simulator. The simulator development has consisted of the simulator core and the graphical user interface. We have used Netsim as the basis for our simulator core. Netsim is a publicly available network simulator originally developed at MIT for ethernet simulation. Netsim is written completely in C, and its source code is freely available and modifiable. The Netsim simulator is quite robust, and it has a rudimentary X interface. We have separated the X interface, the simulator core, and the network protocols.

We have redesigned the Netsim GUI using Tcl/Tk, a script language for GUI development. A typical use of the GUI consists of two phases – the network configuration phase and the simulation animation phase. In the network configuration/editing phase, the student draws simple geometric objects representing network components. Graphical user input is currently limited to the ability to change the parameters of various network components. The network configuration is loaded from a text file specification.

In the simulation animation phase, the system animates simple geometric objects and bitmaps. Our interface currently supports running simulations of pre-loaded network configurations, and animates the network operation. The animation includes the flow of packets

across various links and protocol layers, space-time diagrams between each sender and receiver, and the sending and receiving of data at the application layers of the sender and receiver respectively. The ability of fast prototyping in Tcl/Tk has been very useful in designing and testing different interface modules.

5 Dissemination Activities

The software system has been developed on HP machines running UNIX, and has been ported to Linux running on Pentium processors. We are in the process of making the system and the lab assignments available on the world wide web for instructors in other institutions to use and evaluate them in their networking courses.

6 Evaluation Activities

The first three labs were piloted in two parts in an introductory networking course at The Ohio State University. A student survey was conducted to evaluate the lab component of the course. The survey results are outlined below:

- A total of 49 students responded to the survey.
- 38 students found the labs useful in understanding the concepts taught in class. 6 students did not find them useful, while 5 were neutral.
- Almost all students were in favor of using C as the programming language for these labs.
- Most students wanted some more documentation on the simulator environment. Since the survey, we have improved our documentation process.
- Several suggestions were made for improving the GUI, and we are incorporating these in our interface.
- Some students suggested the need for step through and debugging modes in the simulator. We have already added debugging levels to the code. A step through mode will be added next.

7 Benefits Seen and Expected

The survey also showed that the students found the labs very helpful in understanding the concepts that they were taught in class. We hope that as the labs are developed and are made more robust, they will be a part of any standard networking curriculum.