Proposal to Bucknell University's Undergraduate Research Program
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A Study of Radio Propagation Models in the Simulation of Wireless Ad-Hoc Networks

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<u>Part A:</u> **Project Description**

Wireless networking represents enough of an advance in computing to merit it being recognized as a revolutionary technology. When computers can operate on battery power and communicate with other computers via radio, they can enjoy a freedom of movement that allows their application in areas where the more traditional wired, networked computer was of no help.

Wireless networking technology is quickly becoming mainstream and accessible to average users thanks to infrastructure style wireless networking. Infrastructure networks are commonly found in bookstores, coffee shops, homes, and college campus like Bucknell University. The next step for wireless is *ad hoc wireless networking*, where the network is established without reliance of any form of infrastructure and without any form of human intervention.

Wireless ad hoc networking technology is an active and exciting area of research. Ad hoc networks are helpful in a variety of applications such as like emergency response, remote sensing, and instant messaging. Since ad-hoc networks require no infrastructure, they have a huge potential for quickly deployment situations with minimal overhead. But In order to facilitate these networks there has to be extensive testing on what happens when the networks become large. Since there is no central controlling machine each node added to such a network adds yet another level of complexity to untangle.

In the development of such networks computer simulation is used extensively. Simulation allows for evaluation of system prototypes when their size is potentially large and experimental conditions are hard to control. The value of simulations of wireless networks, however, depends on how closely they can represent the behavior of the real system. Existing simulators for these networks run too slowly for large networks. One such project, the project of the "Simulator for Wireless Ad-Hoc Networks" (SWAN) was started two years ago at Dartmouth College.

SWAN is still an ongoing project and has much room for improvement. What we propose to accomplish this summer is to validate and extend SWAN's models for radio propagation. The United States Geological Survey has created a model for radio broadcasts, the *Irregular Terrain Model* (ITM), which was originally conceived for long-distance broadcasts, such as television and radio stations. A prototype for this model was developed by Evan Richardson, an undergraduate from Dartmouth College. We propose to incorporate this model into SWAN, and compare its estimates for radio signal propagation with experiments in the field. We will use laptops with wireless LAN cards in terrain of our choosing, measure how signals attenuate and compare these numbers with estimates from the simulation model.

Once the ITM validation task is completed we will develop a new radio propagation model for SWAN. This new model will break into "cells" the terrain where a wireless ad hoc network executes. This will simplify the simulation model by reducing the complexity of the mathematics of radio signal propagation. We will attempt to validate this model against experiments in the field, as done for ITM. At the end of the study, we will compare the two models and indicate how fast each one runs in simulations, as well as how accurate they are.

Methods:

Before we get started on our goals, there will be an initial period to get acquainted with the details of the ITM model, its implementation in SWAN, and the SWAN simulator itself. This stage will require reading research papers and studying source code for the simulator and should take about one week.

The second stage will consist of validating ITM by taking laptops out in the field and measuring radio signal propagation on the chosen terrain. The data collected will then be compared to those generated by the ITM model provided by the USGS. If this comparison gives close results, we will proceed to work on integrating the ITM prototype into SWAN, what will be essentially a programming task. This second stage should take no more than two weeks.

The work on the cell-based propagation model, third stage of the project, is likely to consume the next three weeks. It will require us to collect data to create a digital terrain map of a locality, choose cell dimensions on this terrain, and collect data on radio propagation from cell to cell in the grid. We will construct a SWAN model to hold this data together with the digital terrain map, use this information in simulations, and compare the simulations with data from the field.

The final step of the research project will be to use two weeks for compiling all of the summer's results into a research paper for submission to a conference.

We summarize the schedule for this project below into an eight-week timeline. Each week will comprise of forty hours worth of work. The work is slated to begin mid- to late-June and end a week before classes resume in August.

Week 1: Gain familiarity with SWAN and the Irregular Terrain Model.

Weeks 2-3: Validate of ITM and its integration into SWAN.

Weeks 4-6: Collect terrain map data, radio propagation data, and code the cell-based propagation model in SWAN.

Weeks 7-8: Write up results in the form of a conference paper.

<u>Part B:</u> Research environment

Bucknell University possesses all the resources required for this project. The simulation studies will be done on a sixteen CPU computing cluster acquired for this purpose with external funding by Prof. Perrone (Bucknell fund 228233, grant number GFE023). Empirical studies in the field will use Prof. Perrone's own GPS units which can measure terrain elevation as well as providing accurate location information, and laptop computers from the Computer Science Special Projects Laboratory. Prof. Perrone and I will hold formal meetings at least three times a week for a minimum of one hour, in addition to informal interactions according to an open-door policy.