CSIM 19 User Story:
Communication Protocols for Mobile Ad Hoc Networks

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Introduction

Faculty and students at the University of Arizona have used CSIM for almost ten years, in both education and research.

In education, CSIM was first installed on a Unix (Solaris) platform as a supporting simulation tool for two graduate networking classes: Broadband Networks and Multimedia Communications (ECE564), and Computer Network and System Evaluation (ECE577). The first course exposes students to the fundamental techniques, algorithms, and protocols underlying recent technological advances in the fields of wired and wireless networking. Students used CSIM in homework assignments and mini-projects to study a variety of difficult-to-analyze case studies, including TCP's flow control, priority scheduling mechanisms, web servers, etc. In ECE577, CSIM was the method of choice for studying the queueing performance (e.g., buffer overflow probabilities, average delays, etc.) for complex queueing systems. These systems abstract the behavior of packet routers/switches under non-stationary and auto-correlated packet arrival processes. Such systems are not possible to analyze mathematically, and can only be studied via simulations.

On the research front, we used CSIM for several research projects, which include: (1) evaluating the delay and packet loss performance of ATM switches under multimedia traffic, (2) comparing the performance of various media streaming algorithms over wired and wireless links, and more recently, (3) studying routing and medium access protocols in mobile ad hoc networks (MANETs). In all of these projects, CSIM proved its efficacy as a simple-to-learn yet powerful

Application Area:
Wireless Networks

Platform:
Solaris and Tru64 Unix

Version:
CSIM 18

CSIM's Challenge:
Studying routing and medium access protocols in mobile ad hoc networks (MANETs)

simulation engine. For brevity, we report our experiences with CSIM as it relates to the MANET project.

The MANET Project

A MANET is an autonomous system of wirelessly interconnected mobile nodes (see Figure 1). Such nodes (which may represent laptops, cellular phones, PDAs, sensors, etc.) are, in general, free to move randomly and organize themselves arbitrarily. MANETs do not require a pre-existing infrastructure. They may operate in a stand-alone fashion, or they may be connected to the larger Internet through a fixed access point.

MANETs have recently been the topic of extensive research, motivated by the ability of these networks to provide a temporary wireless networking capability in scenarios where fixed infrastructures are lacking and are expensive or infeasible to deploy (e.g., disaster relief efforts, battlefields, etc.).

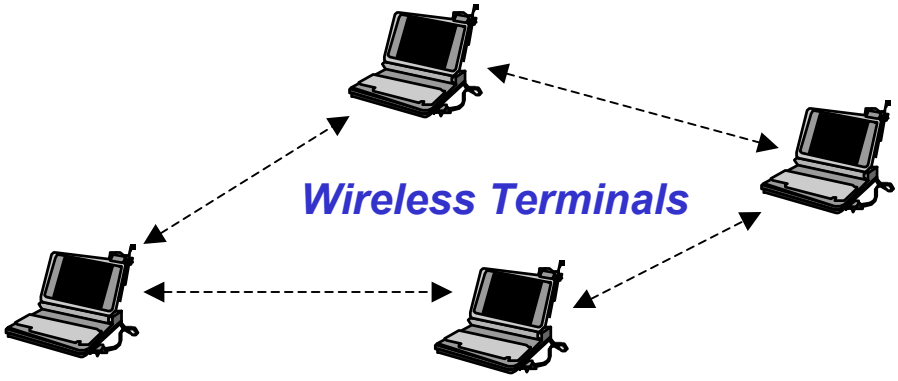

Figure 1: A Mobile Ad Hoc Network (MANET)

Our research has been focused on the design of power-controlled medium access control (MAC) protocols for MANETs. Different scenarios were considered in our designs, including mobile terminals with omni-directional antennas (default case), directional (a.k.a., "smart") antennas, and MANETs with a CDMA capability.

We used CSIM to model the physical layer (i.e., the wireless channel) and several medium access (MAC) protocols for MANETs, including the IEEE 802.11 protocol operated in the ad hoc mode. CSIM makes it easier to model the complex interaction in MANETs, as the user does not need to worry about the parallel execution and timing of events between

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nodes. From the user perspective, CSIM processes appear as if they are running in parallel; this behavior allows the user to write the code as he would write it in real-life implementation. Furthermore, CSIM tools, such as Mailboxes and Facilities, shorten the code size and debugging time significantly.

Figure 2 depicts an example of the type of performance results that we were able to obtain from our CSIM simulation programs. In this figure, we depict the effective network throughput of a MANET under two contending protocols: the IEEE 802.11b CSMA/CA scheme (currently used as the de facto protocol for MANETs) and a newly-proposed protocol called POWMAC. The throughput is plotted as a function of the traffic load at each node in the network. The figure shows that POWMAC achieves a significant improvement in throughput over the 802.11b scheme. These results, obtained using CSIM, allowed us to quantify the significant advantage of POWMAC.

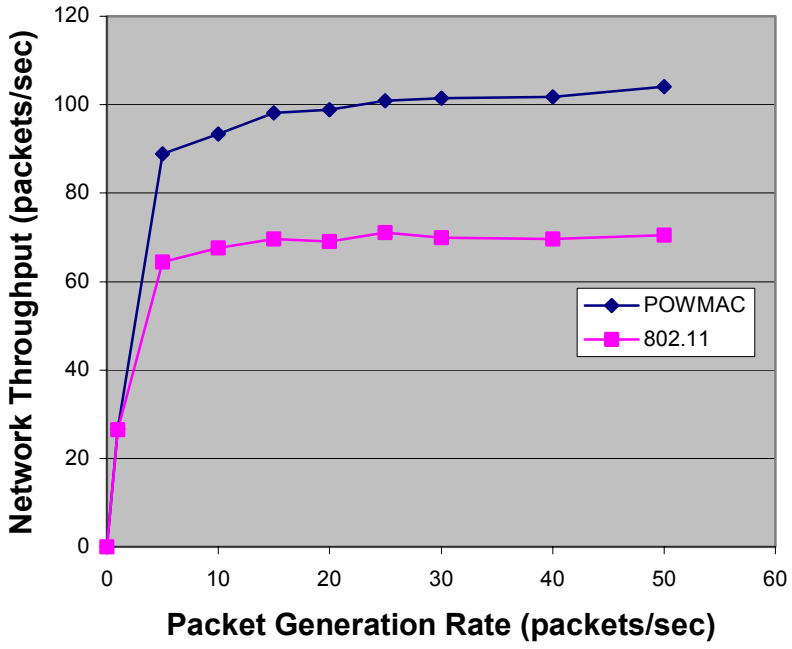

Figure 2: CSIM Simulation Results

"CSIM shortens the development time and effort significantly… Given the short time we had, we could not have built the required models with simple C or C++. CSIM enabled us to simulate complex protocols in a matter of weeks."

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Main Benefits of CSIM

MANETs are extremely complex. Simulating such systems is a very time-consuming process. A critical factor in deciding which simulation package to use is the ability to build the simulation model quickly. For research projects that are focused on making improvements to the MAC or routing layers, the modeler needs to have sufficient flexibility in

adjusting various system parameters and, perhaps more importantly, to be able to integrate user-defined modules (e.g., specific channel models) into the simulation code. Such flexibility is offered by CSIM.

CSIM shortens the development time and effort significantly. For example, by modeling nodes as CSIM Processes and assigning a CSIM Mailbox to each node, the delivery of data packets between nodes becomes an easy task; it is simply a matter of one line of code. Given the short time we had, we could not have built the required models with simple C or C++. CSIM enabled us to simulate complex protocols in a matter of weeks.

Another important aspect of CSIM is that it does not compromise the simulation efficiency or speed for unneeded graphical interfaces and animations, as is done in other competing simulation packages. The CSIM user has complete control over the simulation code, just as if he/she is writing C or C++ programs.

Finally, CSIM is very affordable, costing an order of magnitude less than other simulation packages with comparable capabilities. Such affordability makes CSIM particularly attractive for researchers in academia.

For more information about Dr. Krunz's research and teaching, please visit his web pages:
http://www.ece.arizona.edu/~krunz/
http://www.ece.arizona.edu/~krunz/Classes/ECE577/
http://www.ece.arizona.edu/~krunz/Classes/ECE564/

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