802.11b Performance Evaluation Using the TAS 4500 Channel Emulator

Researchers from Rice University's Center for Multimedia Communications (CMC) recently conducted experiments with the goal of understanding and quantifying the effects of various channel effects on an 802.11b link. In order to manipulate the channel effects, the CMC group used a TAS 4500 channel emulator to connect two specially modified wireless LAN cards mounted in laptop PC's.

Equipment:

- Two Orinoco™ World PC Cards with the antennae removed for isolation
- Two laptop computers running Windows 2000
- One TAS 4500 FLEX RF Channel Emulator from Spirent Communications
- IPERF version 1.1.1 network testing software

Experimental Set-Up:

Hardware:

The 802.11b standard requires feedback between units, so the Rice researchers established a full-duplex connection using both channels of the channel emulator. Each WLAN card was connected to a circulator, which was in turn connected to the output of one channel and the input of the other. In addition, they removed the antennas from the WLAN cards and shielded all of the components to prevent the cards from bypassing the channel emulator. The major components and their connections are pictured in Figure 1.

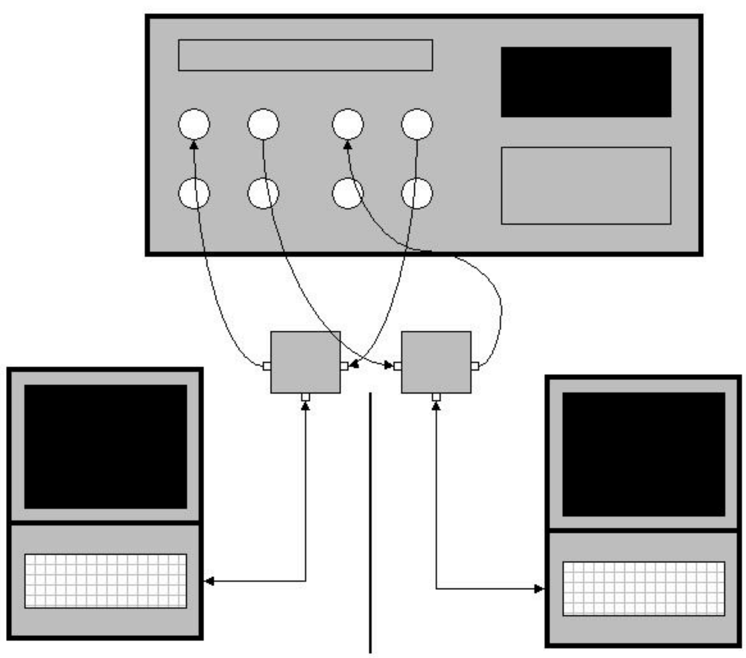

Figure 1. Experimental Set-Up

Software:

Each WLAN card was placed in a laptop computer and configured to operate in peer-to-peer mode on 802.11b channel 10. Using Iperf version 1.1.1 network testing software, the CMC group generated and transmitted data over a UDP link while automatically tracking the datarate and dropped packet statistics in one second increments. The researchers allowed the WLAN cards to independently determine their own modulations (11, 5.2, 2, or 1 Mbps datarates) while they altered the channel parameters and tracked system performance.

Experimental Variables:

In their experiments, the Rice team chose to vary SNR, fading type, velocity, and delay spread. They tested the effect of SNR in the absence of any fading and then gauged the effect of SNR coupled with various fading effects.

In order to control the SNR, the researchers adjusted the attenuation of each path through the channel emulator and monitored the effect on SNR using the Orinoco link diagnostic utility.

Mobile velocity and fading type were controlled directly through the front panel of the channel emulator using built-in fading models.

Different delay spreads were achieved by developing a qualitative, heuristic channel model and then calculating necessary amplitudes and delays for six signal paths according to the model. The channel model arose from observation of many power delay profiles in literature and the conclusion that multipath amplitudes can be reasonably approximated as lying on the hypotenuse of a triangle where the difference in amplitude between the first and last paths is 20 dB. Given this relationship, it is possible to calculate the delay between the paths for any given value of delay spread. The model is represented pictorially in Figure 2.

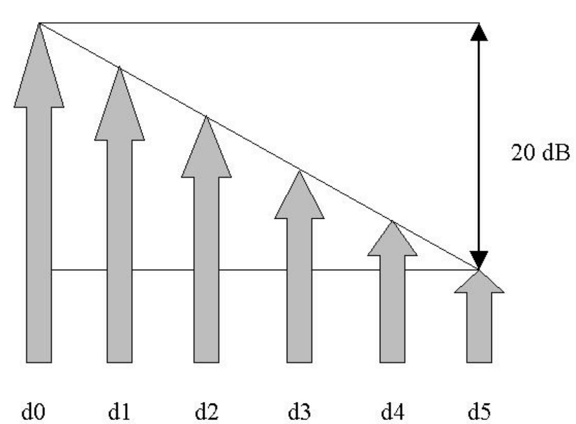

Figure 2. Power Delay Profile Model for Delay Spread Simulation

Results:

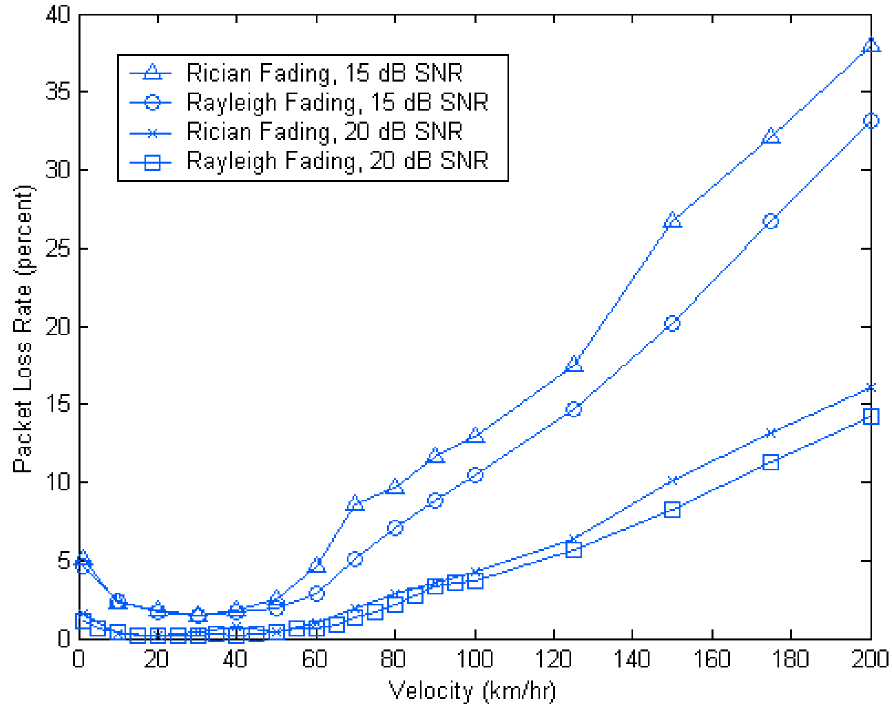

Figure 3. Packet Loss Rate Versus Velocity for Rayleigh and Rician Fading

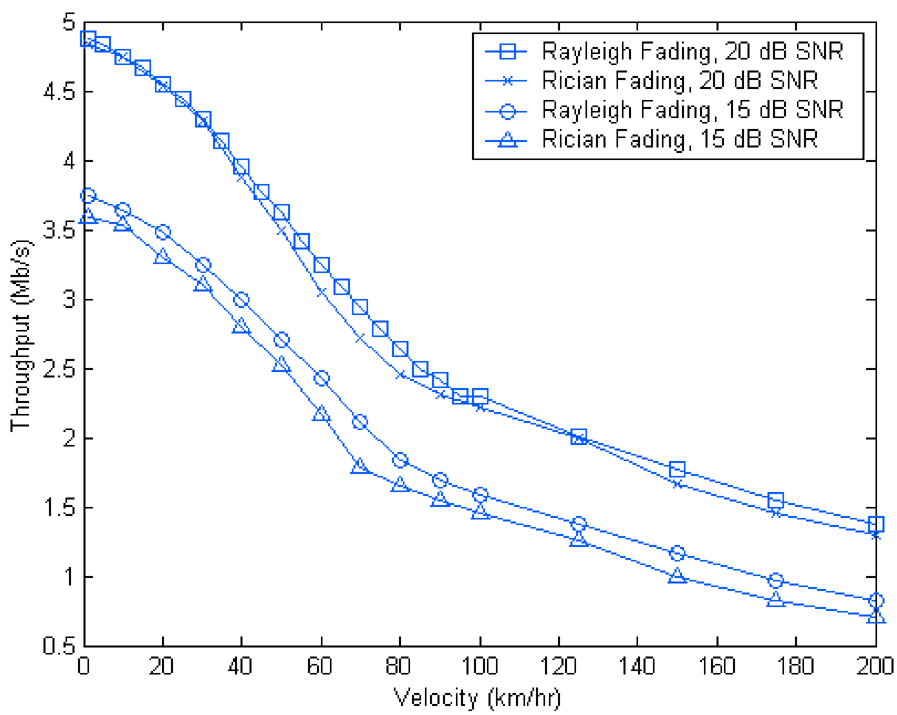

Figure 4. Throughput Versus Velocity for Rayleigh and Rician Fading

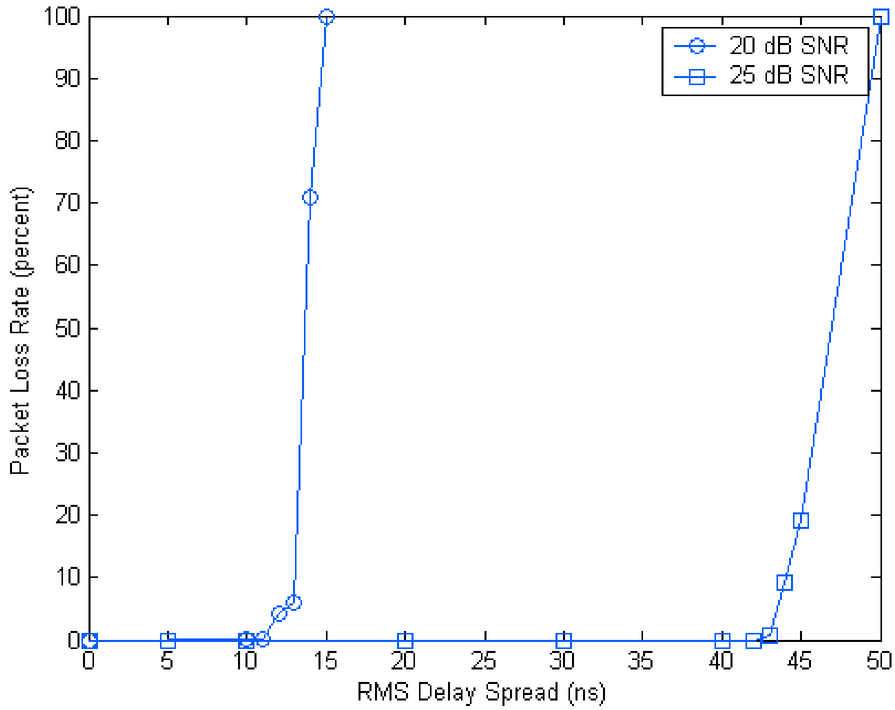

Figure 5. Packet Loss Rate Versus RMS Delay Spread

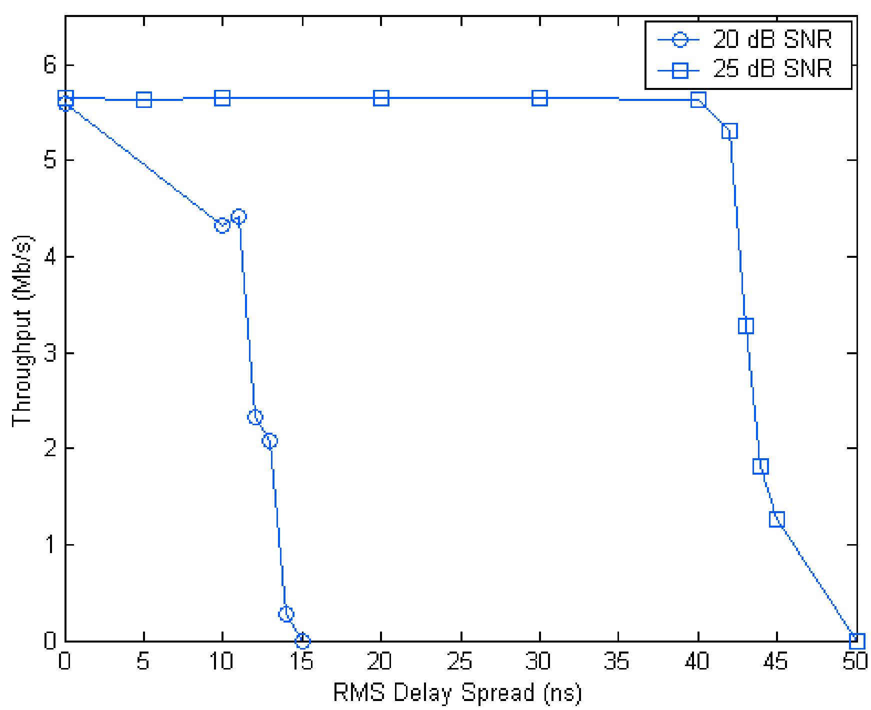

Figure 6. Throughput Versus RMS Delay Spread

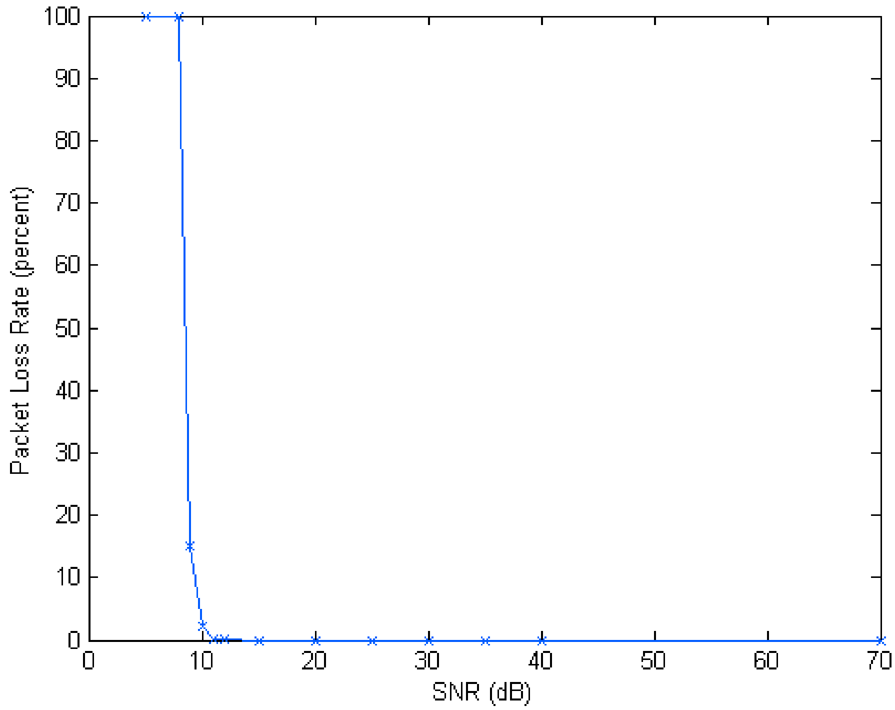

Figure 7. Packet Loss Rate Versus SNR

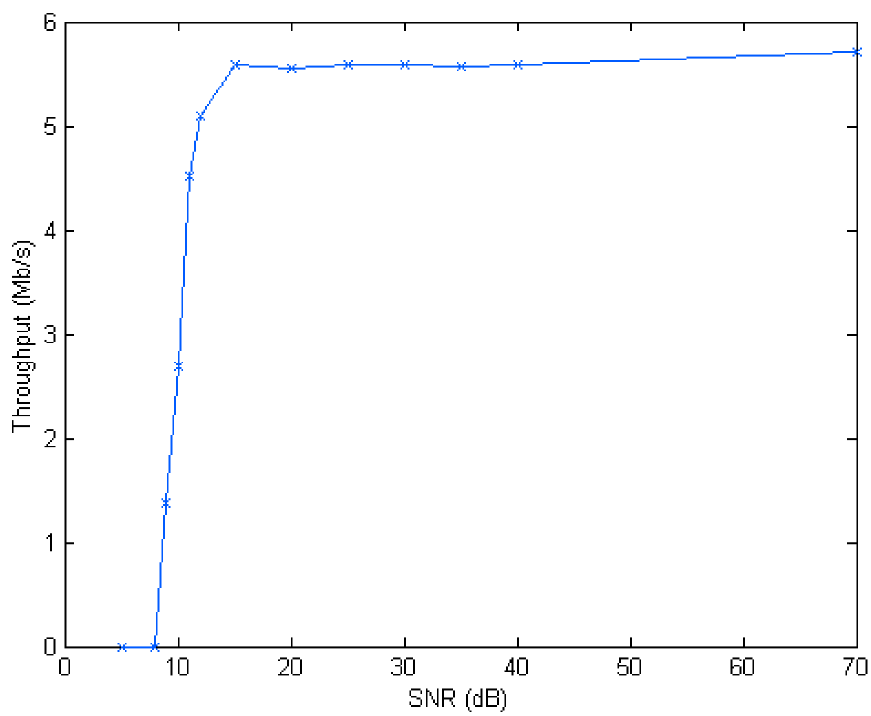

Figure 8. Throughput Versus SNR