Engineering, Operations & Technology
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802.11b PHY models and validation

Workshop on ns-3
March 2, 2009
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Overview

- **ns-3 based simulation framework for assessing interference and coexistence issues in ISM bands**
- **Project involves channel sounding, ray tracing, device testing in environments of interest, and ns-3 validation**
- **Our first steps are to produce a validated 802.11b PHY model for ns-3**

Initial steps

- **CMU clear channel test results are the initial focus**
  - **Paper reference: Characterizing 802.11 Wireless Link Behavior, Glenn Judd and Peter Steenkiste, to appear in Wireless Networks (WINET) Journal, Springer.**

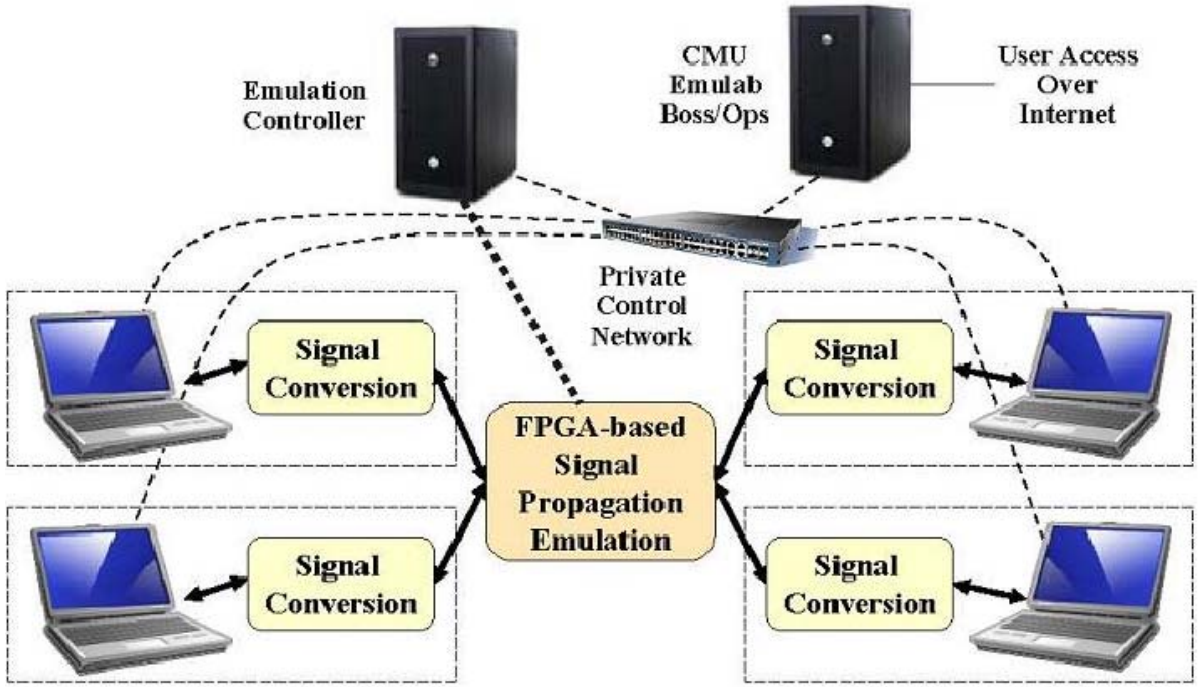


Figure from http://www.cs.cmu.edu/~emulator

Step 1: Clear Channel Sanity Check

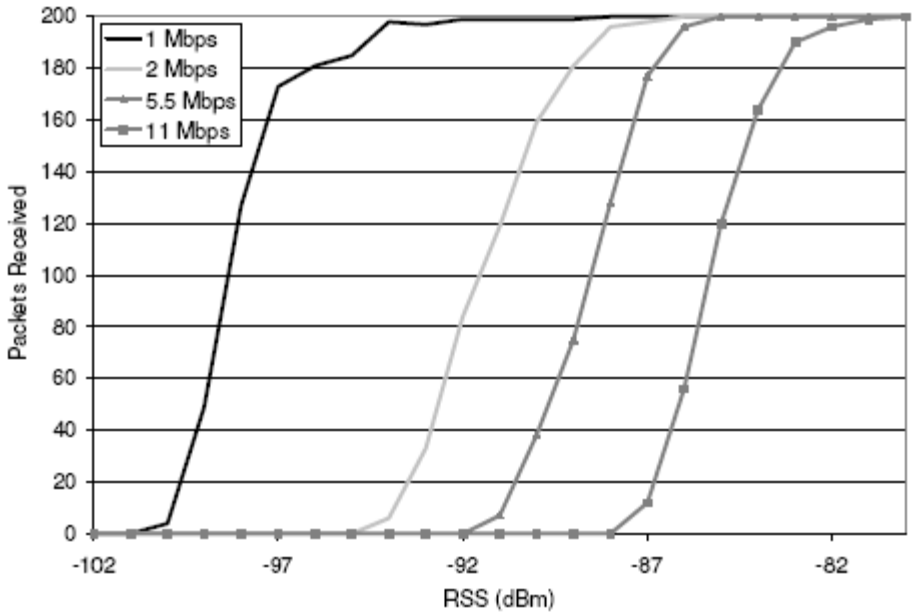


Figure 2: Clear Channel Reception

- **ns-3**
  - **In addition to yans bpsk and QAM, add 802.11b BERs:**
    - **DPSK (Differential Phase Shift Keying): 1 Mbps**
    - **DQPSK (Differential Quadrature Phase Shift Keying): 2 Mbps**
    - **Complementary Code Keying for 5.5Mbps**
    - **Complementary Code Keying for 11Mbps**
  - **Add option to set RSS instead of distance**

Step 2: ns-3 Capture model addition and validation

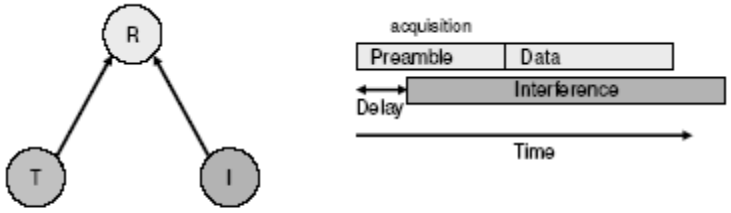


Figure 3: Setup for Capture Under Delayed Interference

- **ns-3: Add capture model based on CMU data**
  - **The CSMA/CA MAC will be validated also in this exercise**

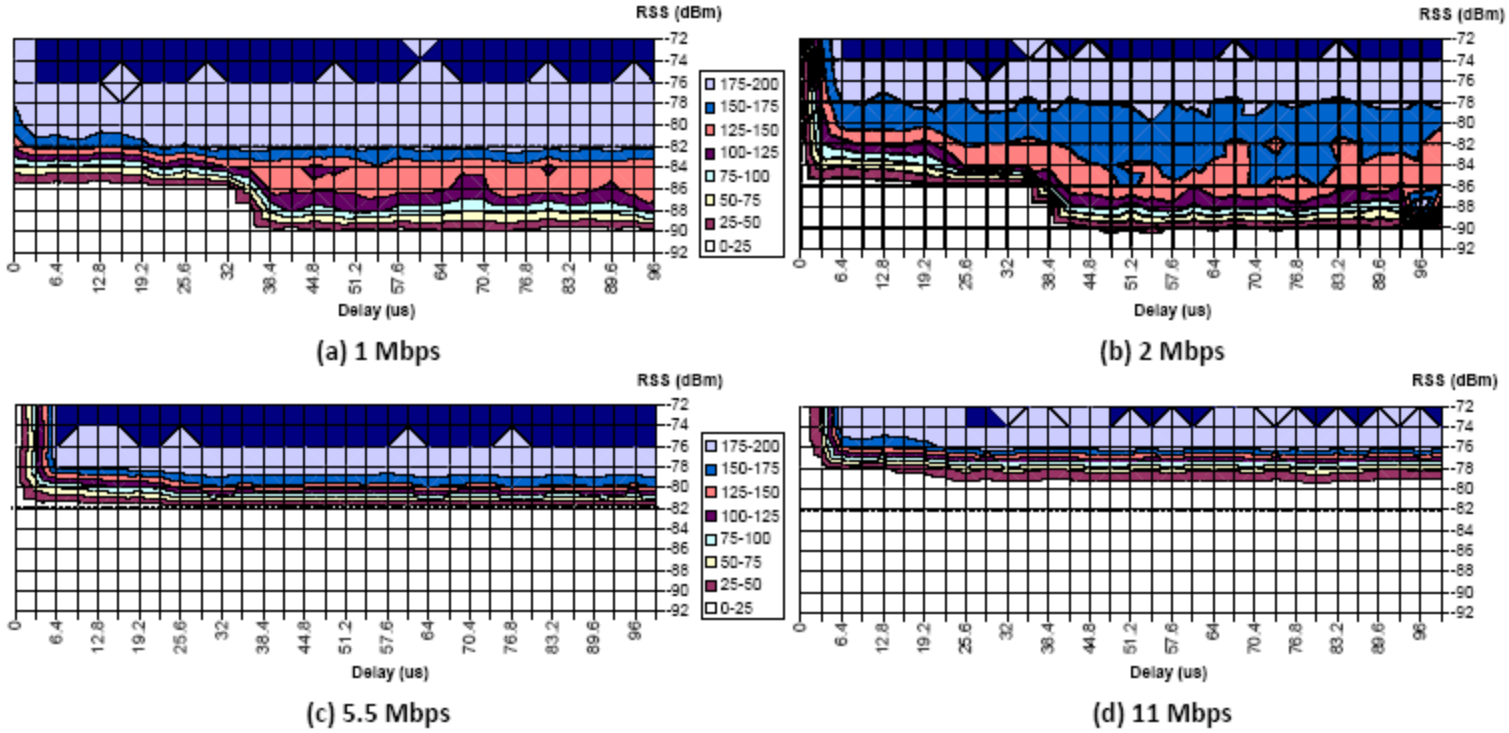
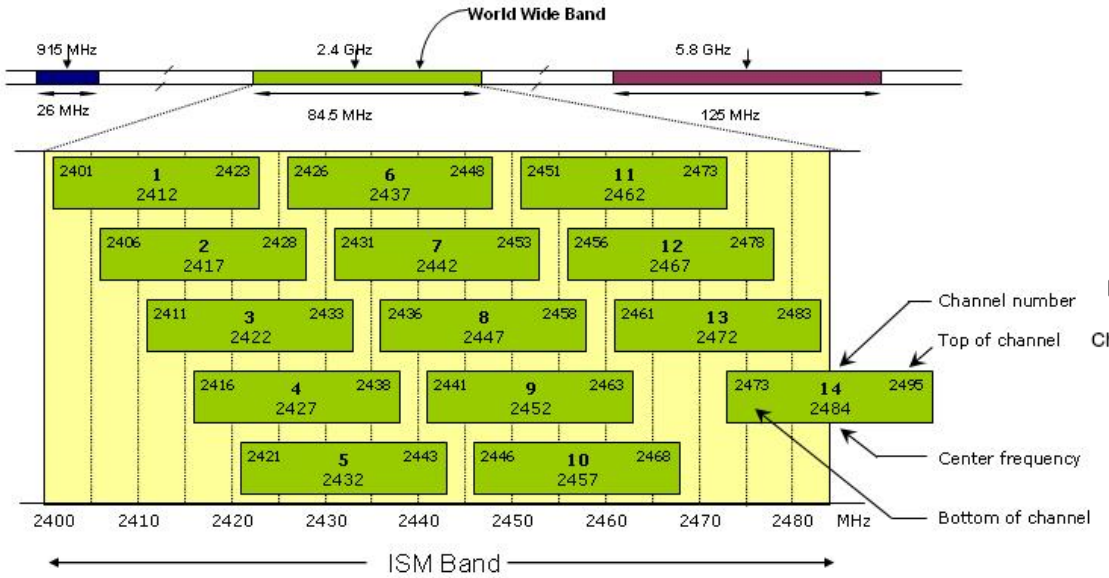


Figure 4: Capture Under Delayed Interference Results

Step 3: ns-3 Off-Channel modeling and validation



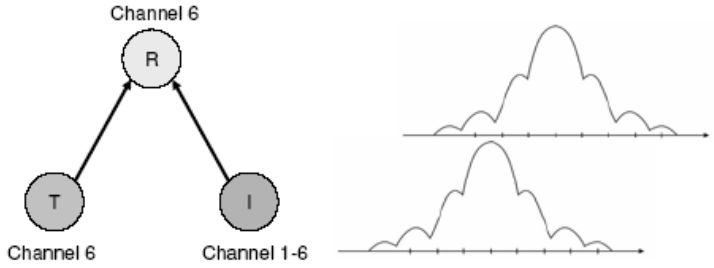


Figure 7: Off Channel Interference Setup

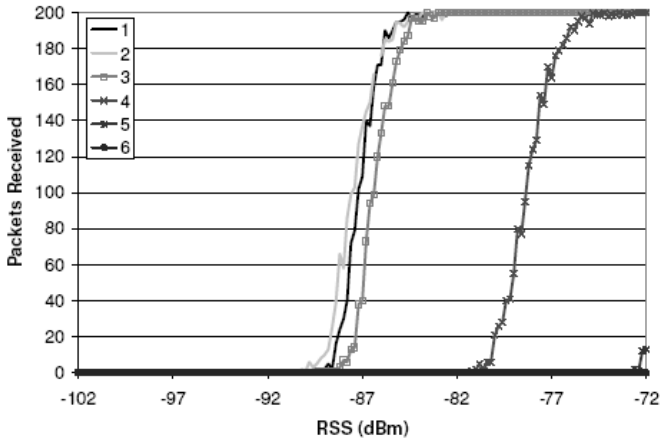


Figure 9: Off-channel Interference, 11 Mpbs, large delay, -72 dBm Interference

- **ns-3: Add off-channel model**

Step 4: Bluetooth-like experiments

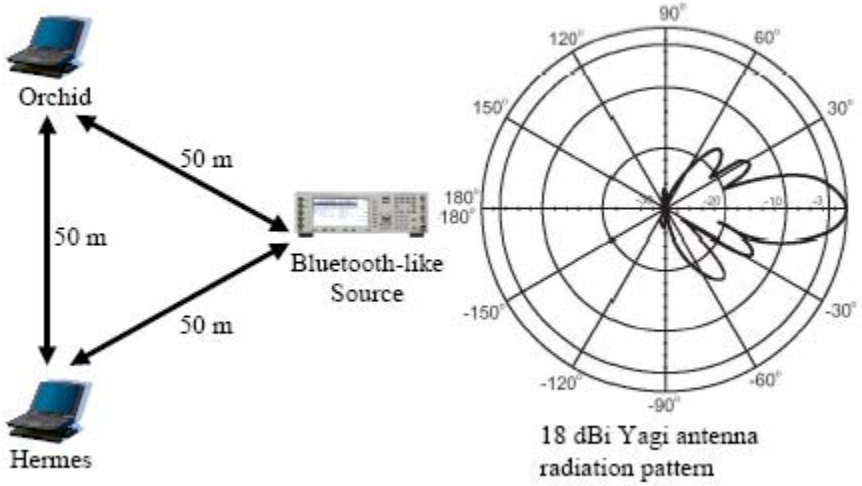


Figure 11. Directional Antenna Topology

ns-3: Extend off-channel experiments with abstracted Bluetooth interference

Seeking alignment with CMU results

- **References for our BER curve generation:**
  - **Prism HFA3683 datasheet**
  - **Matlab Communications Toolbox**
  - **Proakis, Digital Communications textbook**
- **BER model impacts the results**
  - **Investigated two sets of BER curves**
    - **IEEE 802.15.2-2003 (also presented in the book "Wireless Network Coexistence" by Robert Morrow)**
      - It uses BPSK/QPSK for 1 Mbps and 2 Mbps instead of DBPSK/DQPSK
      - It assumes optimal decoding with a bank of 256 correlators in the receiver (Prism uses 64 correlators for 11 Mbps and 4 correlators for 5.5 Mbps)
      - The order of 2 Mbps and 5.5 Mbps is reversed from measurements
    - **BER from Proakis' textbook and Matlab simulink simulations**
      - DBPSK and DQPSK equations used for 1Mbps and 2 Mbps
      - Matlab berfit() was used to generate ber equations based on Monte Carlo simulation (still looking for good theoretical curves)

802.11b BER model: IEEE 802.15.2-2003

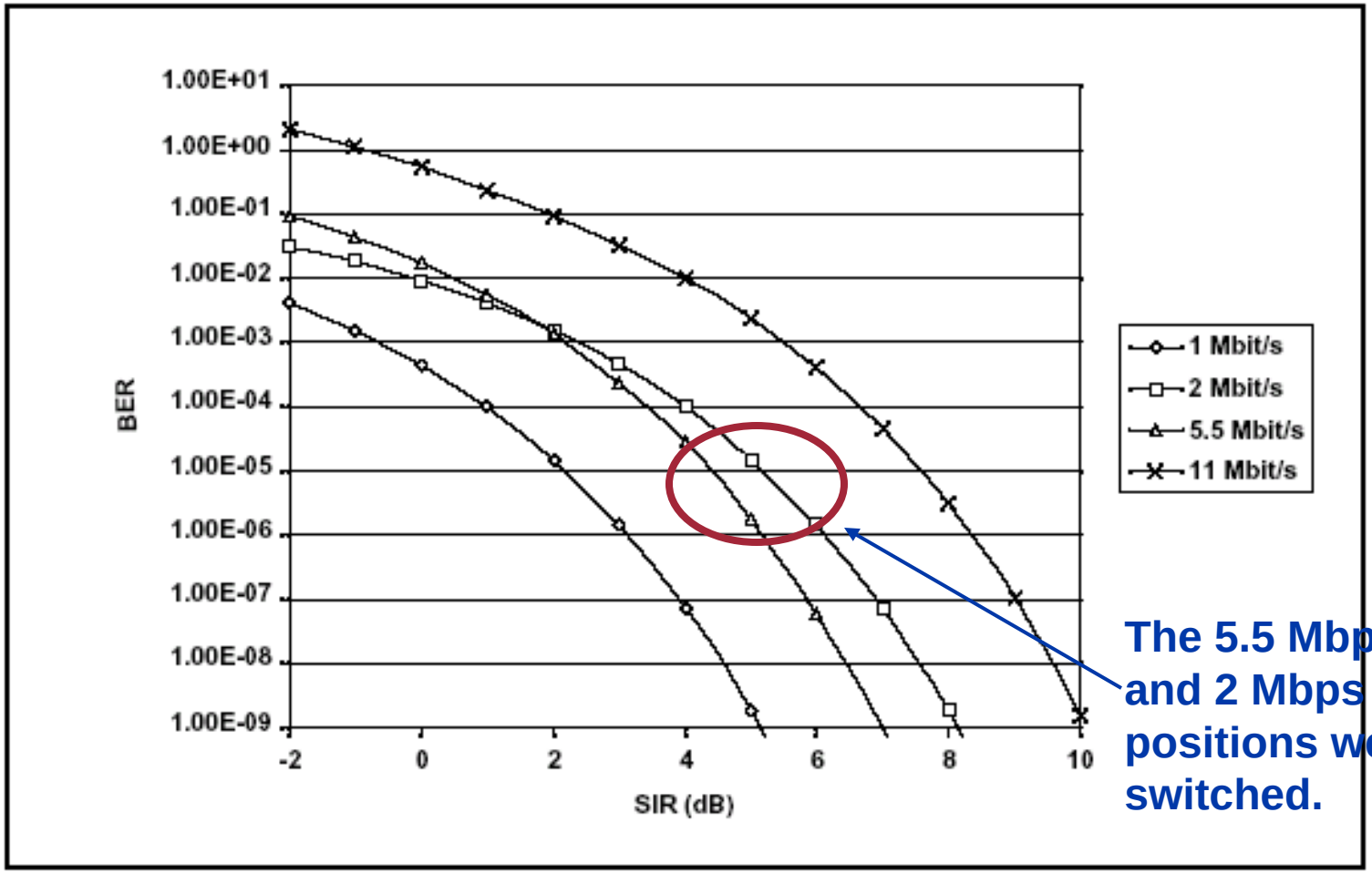
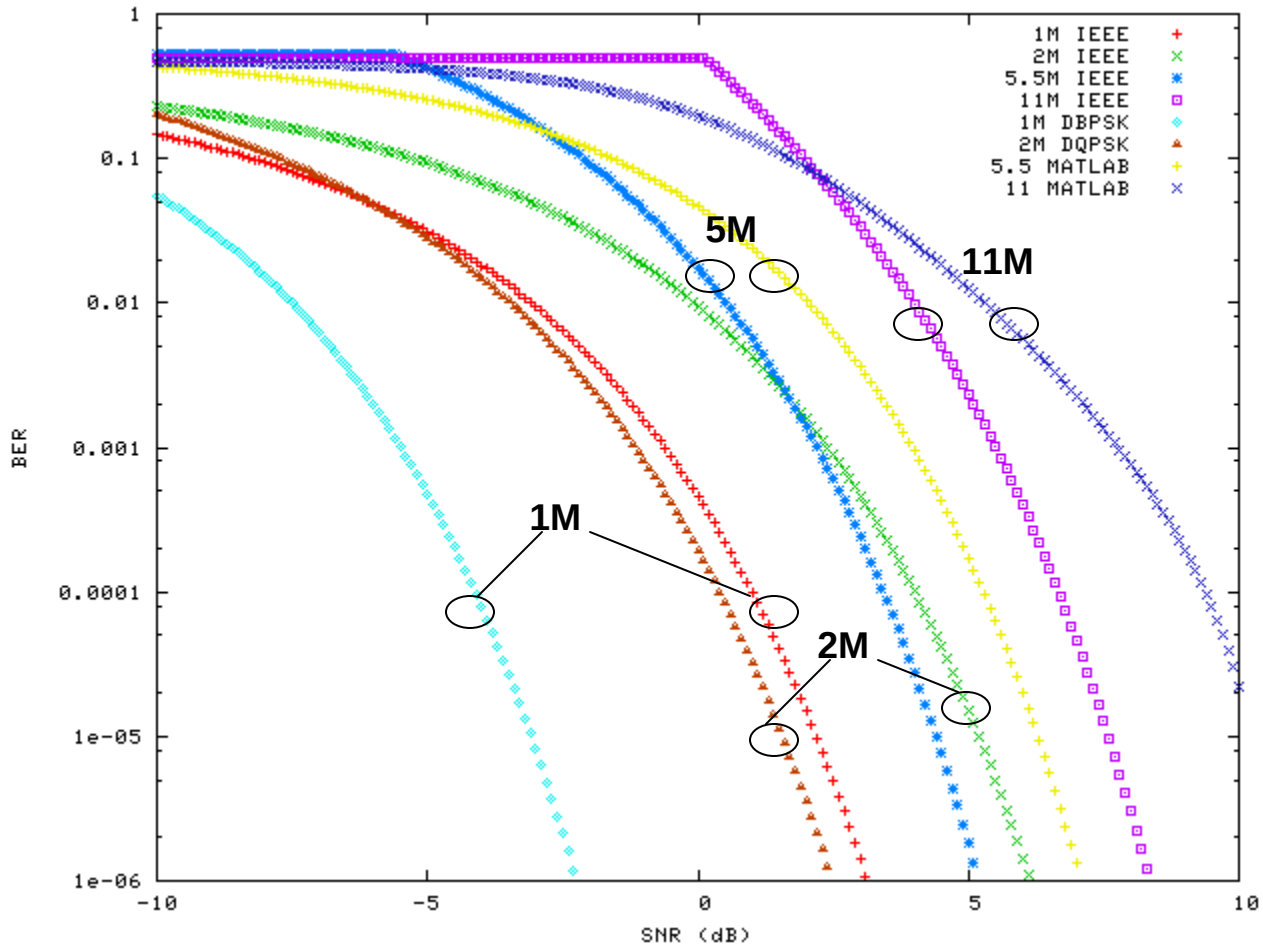
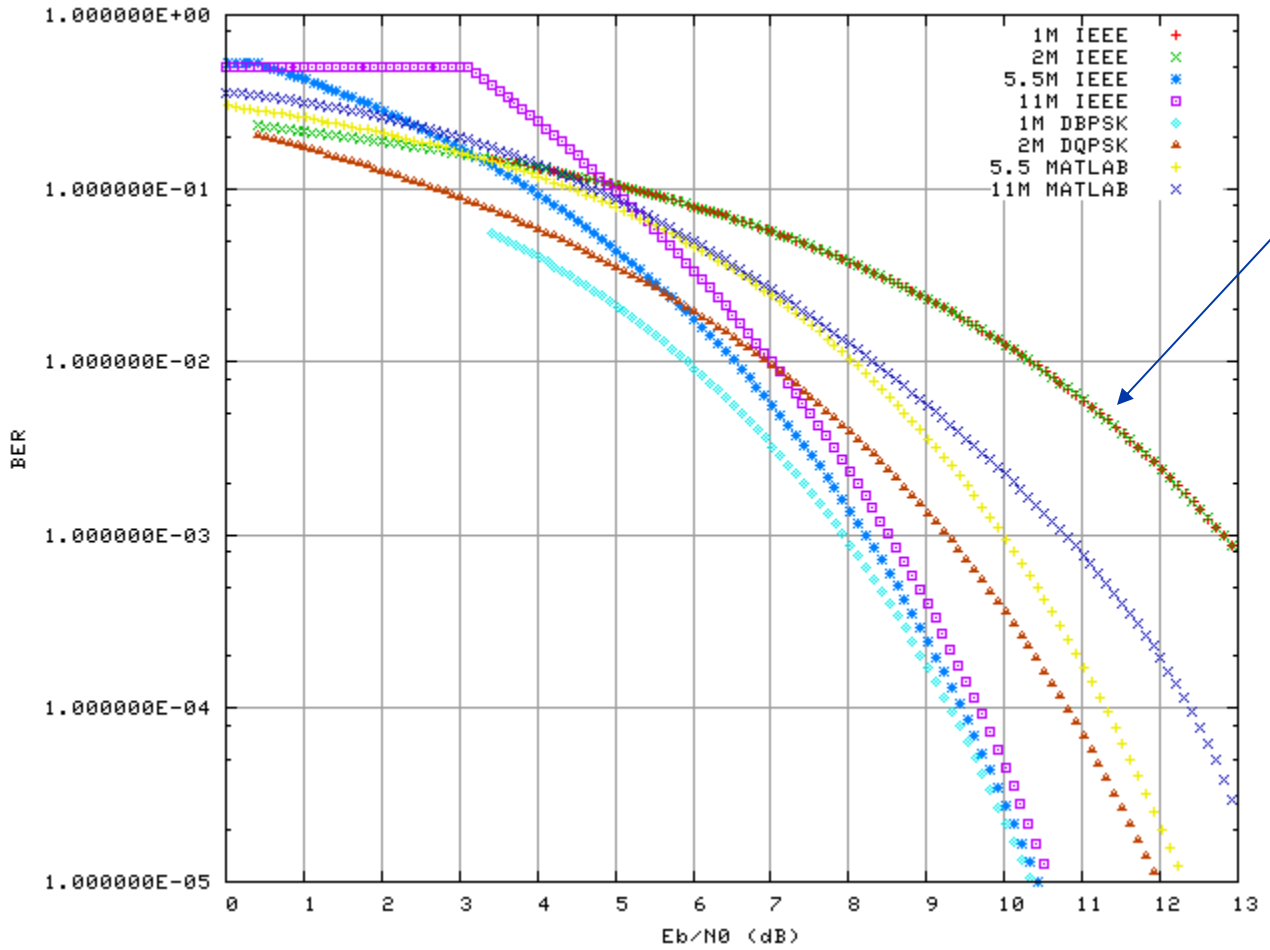


Figure C.4—BER versus SIR for 802.11b modulation types

Two sets of BER vs SNR

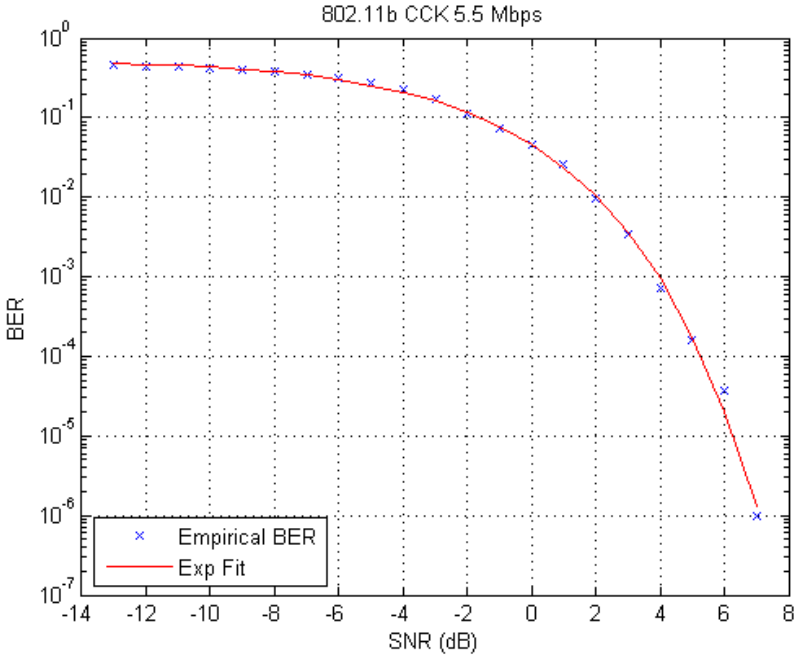


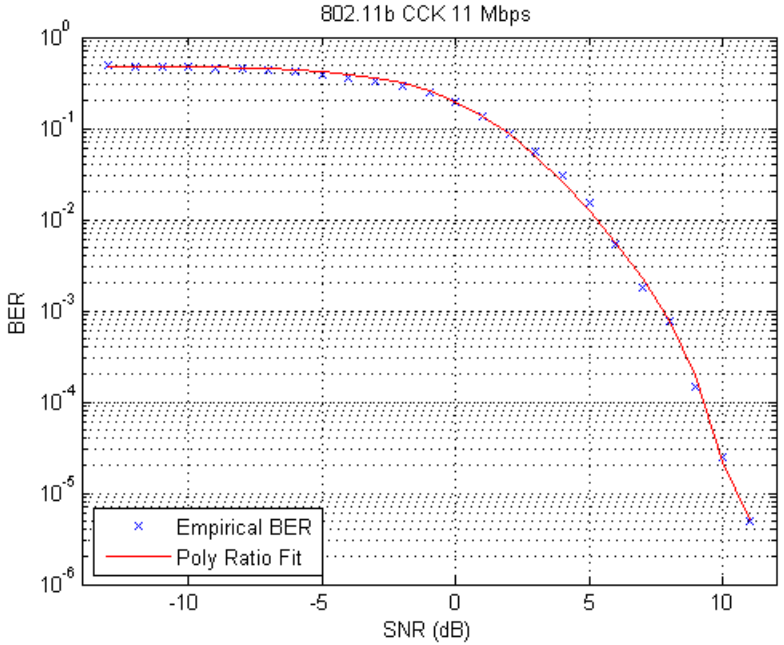
Two Set of BER vs Eb/N0



IEEE model uses BPSK/QPSK for 1Mbps and 2 Mbps

Matlab berfit of CCK 5.5 mbps and CCK 11 mbps modes





CMU match experiments with IEEE model

The spacing does not match.

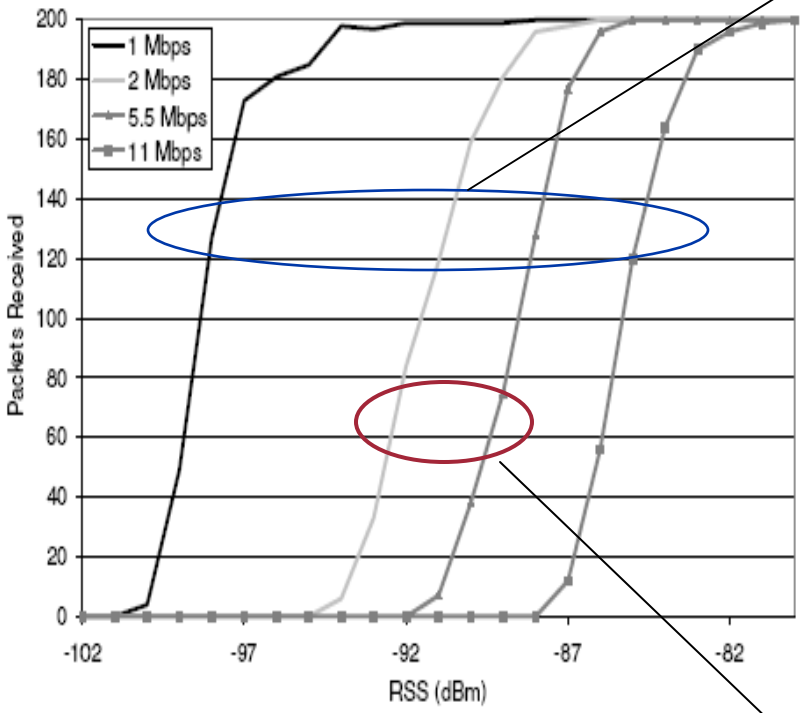
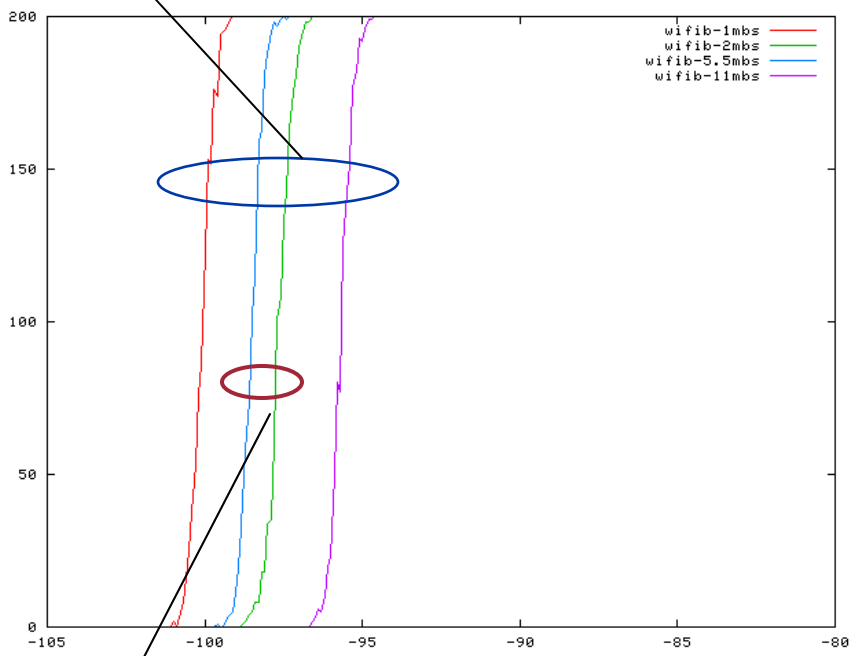


Figure 2: Clear Channel Reception



The order does not match.

CMU match experiments with alternative model

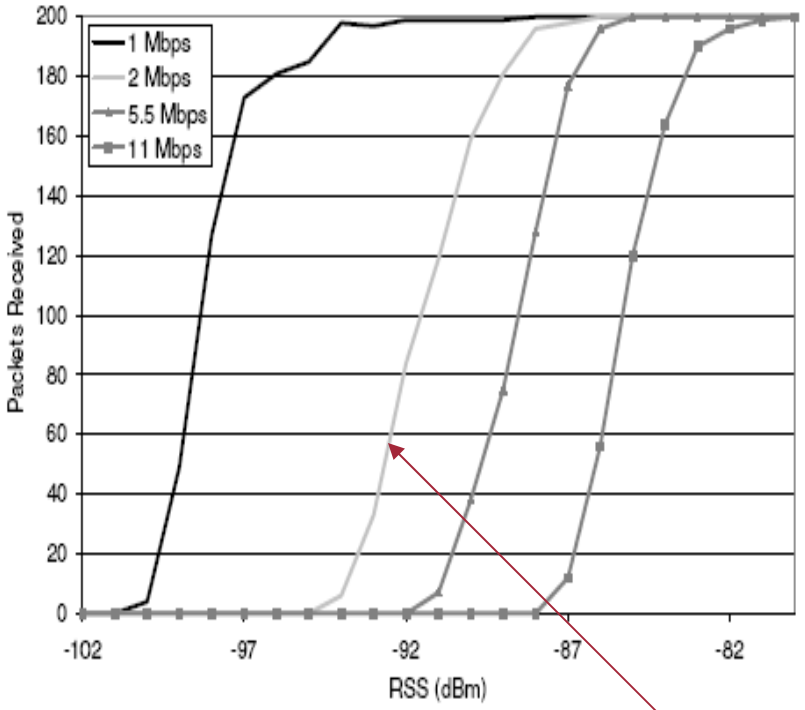
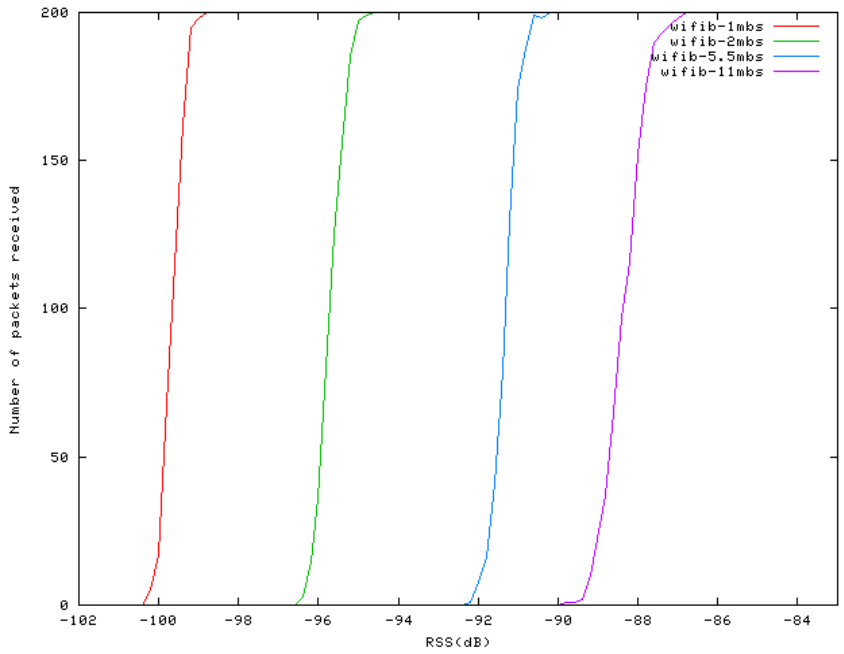


Figure 2: Clear Channel Reception



Need to investigate the original experiment data set. It seems that 2 Mbps curve shifted to the right and it does not match the DBPSK and DQPSK theoretical separation expectation.

Output of this work

- **Validated BER tables for IEEE 802.11b PHY, clear channel**
  - **(more validation results as we go along)**
- **Documentation on our validation methodology and results**
  - **ns-3 needs to start documenting this type of work in an organized fashion**