IEEE 802.11
Wireless Access Methods and Physical Layer Specifications

Title: Signaling Methods of IR PHY

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Abstract

This paper compares the BER performance of several possible modulation methods for IR PHY of wireless LANs based on the common ground. We found that Manchester code is the best one for 10M and 20M bps transmission, while a new coded modulation (modified run length code) outperforms all other methods at 100M bps.

Introduction

Several methods have been porposed to the IEEE 802.11 as candidates of IR modulation methods. However, their performance has not been compared based on the common ground. In this paper, we send the same pulse to the same channel for different modulation methods to evaluate their BER performance. The modulations that we consider include OOK, NRBI, Manchester, 16-ary PPM, and MRLC (modified run length code) that is first time to appear in IEEE 802.11 and literature. MRLC is created by the author for very high rate IR transmission.

System Description

OOK and NRBI which is also based on OOK is demodulated under the assumption that a precise decision threshold is known by the receiver while we employ an optimal receiver for OOK. For Manchester code, we use a differential demodulator which is also optimal for Manchester code (or known as binary PPM). For 16-ary PPM, we adopt an MAP optimal receiver for demodulation.

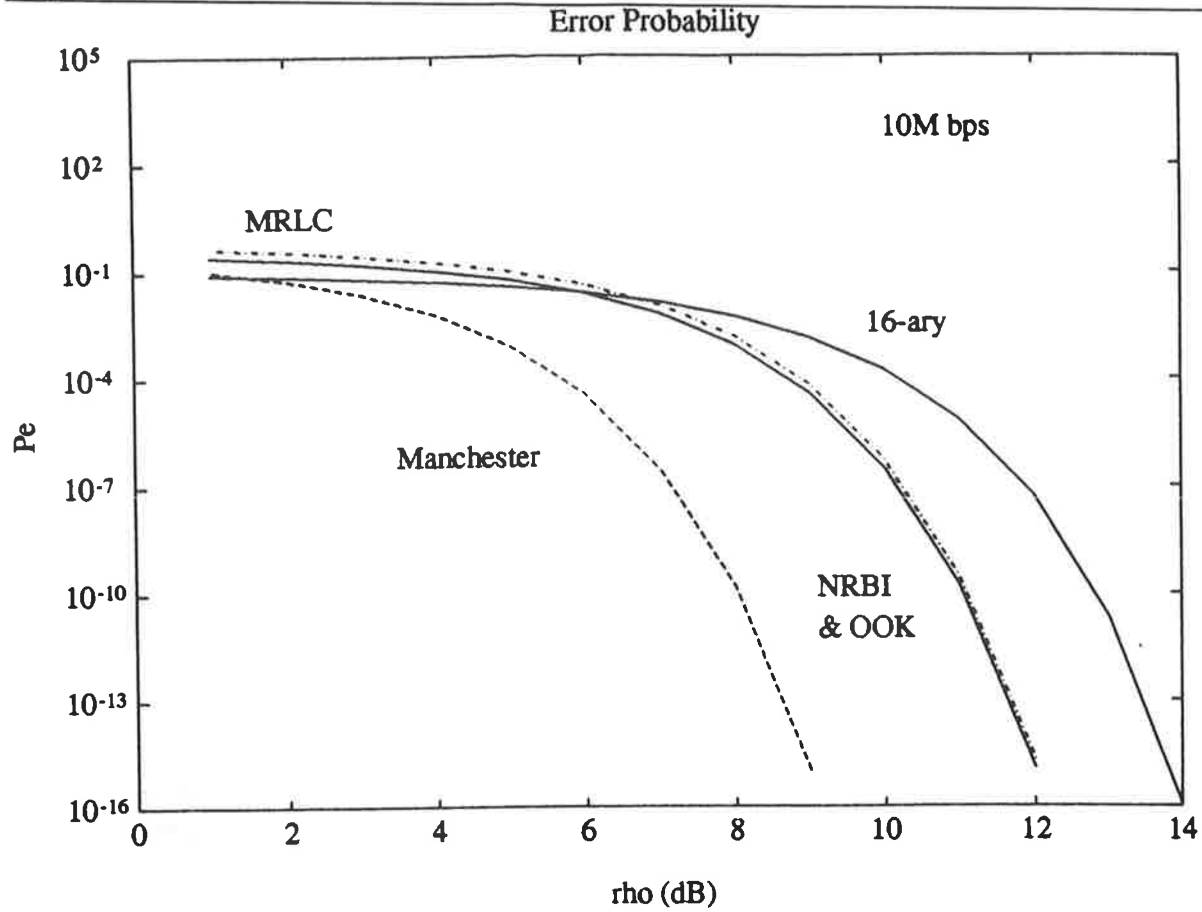
MRLC is also based on OOK modulation for each "1" or "0", however, we combine a modification of run length code as a maaping for this new coded modulation. The coding rule is pretty simple and as follows. We encode two bits (00,01,10,11) into different code words as "01", "001", "0001", "1000". The resulting spectral efficiency is 0.615 (0.5 for Manchester code; 0.25 for 16-ary PPM; 0.96 for NRBI, 1 for OOK). Here, we define spectral efficiency to be (information bits)/(average required slots). The decoding rule is also pretty simple (thus,
high rate transmission is possible).

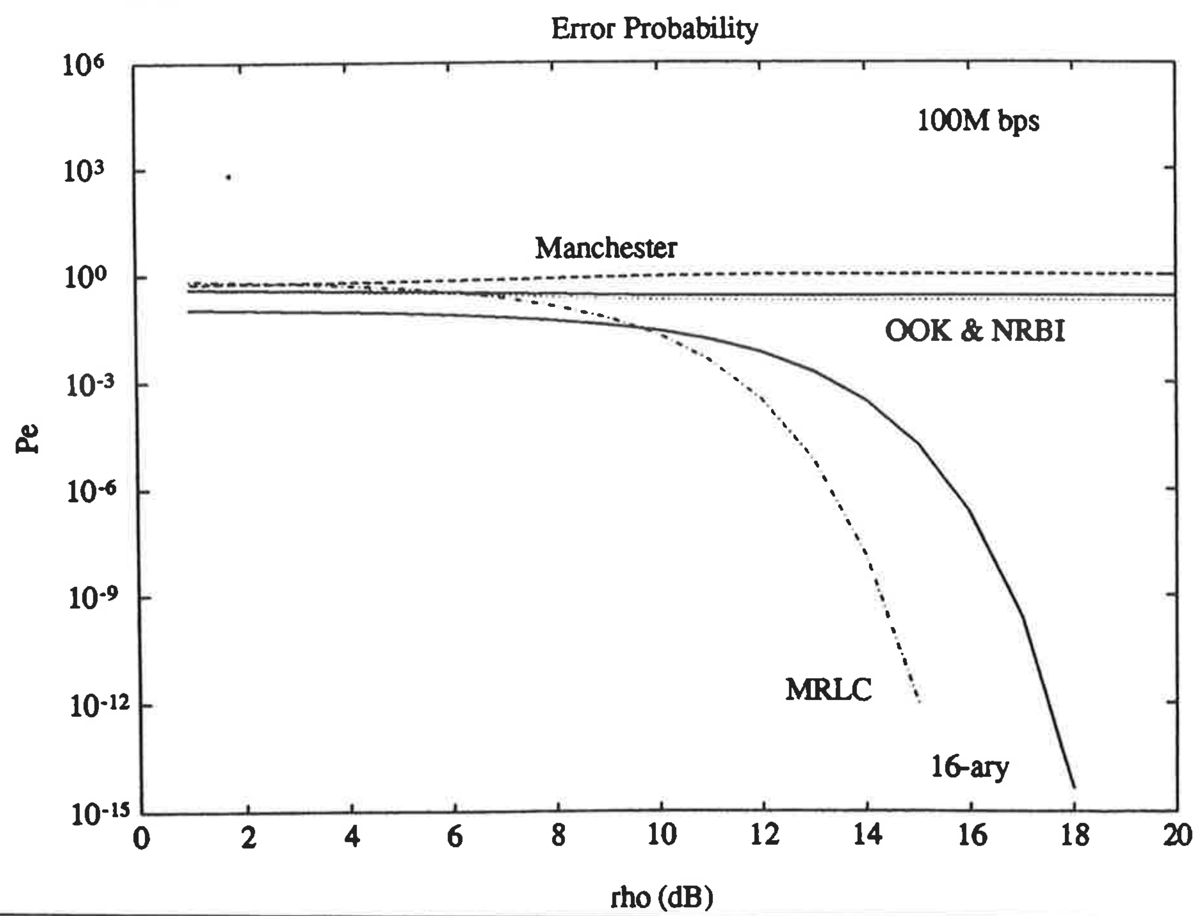
Step 1a: If a new code word begins with "0", count the number of zeros until next "1". If this number is not 1,2,3, claim uncorrect error. If yes, map the codeword to a combination of two bits.
Step 1b: If a new code word begins with "1", count the number of zeros until next "1". If this number is 0,1,2, the beginning "1" must be an error and has to decode as "0". If this number is "3", we map the codeword to the corresponding two bits. Otherwise, it is an uncorrect error.

Now, we use the same pulse (rectangular) for all modulations. For 100M bps, the pulse duration is 2.5 nsec; for 20M bps, it is 12.5 nsec; for 10M bps, it is 25 nsec. The reason to use such durations is that these are the slot durations for 16-ary PPM. The channel model that we use is based on the measurement of UC Berkeley [1]. We consider a superposition of two exponential for the equivalent channel impulse response. The separation of these two exponential functions is 10 nsec while the most delay spread is between 5-13 nsec. After 50 nsec, this overall impulse response is basically fading away. The "height" or "amplitude" of the second "path" is 0.5.

Results

The following three figures depict the performacne of these modulations at 10M, 20M, 100M bps. Not surprisingly, OOK and NRBI are alwyas with similar performance. At 10M and 20M bps, Manchester has the best performance (around 3dB better than OOK at 10M bps; around 2.5 dB at 20M bps). At 100M bps, MRLC has the best performance while only 16-ary PPM has close BER performance with 2.5 dB degradation or so.


Error Probability
10M bps
MRLC
16-ary
Manchester
NRBI
& OOK
Pe
rho (dB)
10^5
10^2
10^-1
10^-4
10^-7
10^-10
10^-13
10^-16
0
2
4
6
8
10
12
14


Error Probability
100M bps
Manchester
OOK & NRBI
MRLC
16-ary
Pe
rho (dB)
10^6
10^3
10^0
10^-3
10^-6
10^-9
10^-12
10^-15
0
2
4
6
8
10
12
14
16
18
20